ILLINOIS NATURAL HISTORY SURVEY

Assessing the ability of a long-term fish-monitoring program to detect effects of dredged material placement within the Upper Mississippi River System.

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Abstract

This study attempts to characterize dredged material placement effects, on a reach wide level for La Grange Reach, Illinois River and Pool 13, Mississippi River using U.S. Army Corps of Engineers, Rock Island District site-specific placement data and Long Term Resource Monitoring Program (LTRMP) fish data. Fish catches were compared between dredged material placement areas and nonplacement areas to determine if there was a difference. Within La Grange Reach, several species were found to have significantly lower catch rates on modern placement sites: black buffalo *Ictiobus niger*, flathead catfish *Pylodictis olivaris*, and longnose gar *Lepisosteus osseus* (Day electrofishing; $P < 0.0007$); brown bullhead *Ameiurus nebulosus* and flathead catfish (large hoop netting, $P < 0.002$); common carp *Cyprinus carpio* (small hoop netting, $P < 0.003$); river carpsucker *Carpiodes carpio* (minnow fyke netting, $P < 0.002$); and bullhead minnow *Pimephales vigilax*, golden shiner *Notemigonus crysoleucas*, and silverband shiner *Notropis shumardi* (seining, $P < 0.002$). No species exhibited significantly higher catch rates on placement sites. Within Pool 13, there were no significant differences of catch rates detected using placement data. Reach wide species richness, based upon presence/absence data, was not significantly different between placed and un-placed sites as tested with Non-metric Multidimensional Scaling (NMDS) within either reach sampled. Community analysis using NMDS suggested no overall changes or long-term impacts on fish communities. Although there appears to be significant differences in day electrofishing results, the global R from Analysis of Similarity (ANOSIM) indicates little separation between the placed and un-placed fish assemblages. Low sample sizes for un-placed sites are likely contributing to the low power to detect differences, which is supported by the conclusions from *post-hoc* power analysis. Future studies need to look into other reaches such as Pool 26 where dredging is more frequent and possibly provide an opportunity for increase sample sizes.

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Introduction

Dredging activities are essential to maintain navigation waterways due to sedimentation and occur in most of the world's navigable rivers (Paipai 2003). One such river system that has been dredged for many years to allow shipping traffic is the Upper Mississippi River System (UMRS). For example, in the Illinois Waterway (IWW, one arm of the UMRS navigation system), 98 million tons of cargo was shipped in 2002 alone (Burroughs 2003). Evidence of the need for dredging comes from the fact that 8.2 million tons of sediment is deposited within the IWW annually (Demissie et al. 1992). The Water Resources Development Act of 1986 (Public Law 99-662), recognizes the Upper Mississippi River System as both a nationally significant ecosystem and a nationally significant commercial navigation system.

The history of dredging in the Upper Mississippi River (UMR) began in the 1800's. In the mid 1800's, sandbars and snags were removed to allow steamboat access to the upstream reaches (Fremling 2005, Ockerson 1898). Ecological concerns with dredging activity include the impacts on aquatic and terrestrial flora and fauna at both the dredged site and also where the dredged material is placed (Schramm 2004, Koel and Stevenson 2002). Historically, the most common placement of dredged material within the UMRS has been on the riverbank or shoreline adjacent to the dredging activity. Much of this dredging is done by hydraulic cutterhead dredging equipment whose discharge is carried to a placement site by floating pipeline. Dredged material can be placed on shoreline, or placed in an upland area and can be moved at the rate of 350 cubic yards per hour, up to 5,500 feet, and up to 1,500 feet inland (IWW-Fact Sheet on maintenance dredging, U.S.

Army Corps of Engineers, Rock Island District, Alois DeVos , Dec. 2004). Shoreline placement may lead to material being eroded back into the river during high water events, moved downstream, and impacting biota in these habitats (Schramm 2004, WEST Consultants, Inc. 2000). Eroded bankline sediment could aggrade downstream, further exacerbating both channel maintenance and ecological concerns at a different location. With improvements in technology and concern for environmental health, dredged material is being moved out of the flood plain of rivers to uplands, behind levees, and even barged to urban areas where soil is in need (Marlin 2003, WEST Consultants, Inc. 2000).

Initial federal authorization for maintenance dredging of the nine foot navigation channel began with the River and Harbor Acts in 1927/1930. The present federal dredging regulations originated in the Federal Water Pollution Control Act of 1972. Section 404 of this Act regulates the disposal of dredged material into navigable waters through permits that are referred to as 404 permits (Burroughs 2003). Burroughs (2003) notes that the Rock Island District, U.S. Army Corps of Engineers, (here after referred to as Rock Island District), issues itself 404 permits for maintenance of the navigation channel within its district and regularly reviews evaluations of these activities. Burroughs (2003) states that a subcommittee of the Fish and Wildlife Interagency Committee (FWIC) was formed in 1998 as a collaborative committee between both federal and state resource agencies to facilitate the 404 process by creating, managing, and discussing: 1) study plans 2) funding and 3) adequacy of research efforts of channel maintenance within Rock Island District.

This study looks at the question: what effect does bankline placements of dredged material have on fish communities? This *post hoc* study uses fisheries data provided by the Long Term Resource Monitoring Program (LTRMP) and dredged material placement data provided by the Rock Island District. The LTRMP monitors fish populations within six UMRS reaches, five on the Mississippi River (Pool 4, Pool 8, Pool 13, Pool 26, and Open River Reach circa Cape Girardeau, Missouri), and one reach on the Illinois River (La Grange). The LTRMP has visited over 24,791 sites since 1993 with over 3 million fish of 134 species being collected from six study reaches of the UMRS. Only data from reaches sampled within the Rock Island District was used for analysis (Pool 13 and La Grange Reach). The Rock Island District provided dredged material placement location data in a Geographical Information System (GIS) format. Using ArcView 3.3 (ESRI 2002) GIS we were able to combine biotic (fish abundance and fish assemblages) and abiotic (site information and dredged material placement) information. Creation of this dataset enable statistical comparisons of fish catch data based upon location and date of placement from the two study reaches.. Our specific objective was to test the hypotheses that 1) Dredged material placement does not affect fish abundance and 2) Dredged material placement does not affect fish assemblages. This analysis used 12 years of fish community monitoring data from the LTRMP and the dredging locations span 64 years from two reaches of the UMRS.

Methods

Study area

The UMRS is the portion of the Mississippi River and its tributaries upstream of the confluence with the Ohio River, not including the Missouri River (Figure 1). The IWW is the navigable portions of the Illinois River and canals that connect this river to Lake Michigan. The Rock Island District is responsible for maintenance dredging within 314 miles of the Mississippi River from Guttenberg, Iowa, to Saverton, Missouri, and 268 miles of the IWW from Chicago, Illinois to the LaGrange Lock and Dam, southwest of Beardstown, Illinois.

Figure 1. Map of the Upper Mississippi River System (UMRS), the six study reaches sampled by the Long Term Resource Monitoring Program (LTRMP).

Dredged material placement data

Geo-referenced data identifying dredged material placement was provided by the Rock Island District. Location data from dredging activities has been collected by the Rock Island District using GIS technology since 1998. Prior to 1998, data for placement was based upon field maps created at time of placement and then digitized. Historical placement records exist for placements from 1940 to the present. Within the Rock Island District, two LTRMP study reaches are present; La Grange Reach, IWW and Pool 13, Mississippi River (Figure 1). Only placement data from these two reaches were used.

Fish assemblage data

The LTRMP fisheries data were mined for the time period 1993-2004 from two reaches of the UMRS (La Grange Reach and Pool 13). The data used for this analysis were restricted to this time period because beginning in 1993 the LTRMP evolved from a fixed site sampling program to one with a more statistically robust stratified random sampling protocol. Only data from sites fished with shoreline gears on main channel border habitat were used. The main channel habitat (mcb-u in LTRMP procedures manual Gutreuter et al. 1995) is without features such as wingdams. In total, 1,968 sites from both study areas were located within the main channel border area where placement occurs (Table 1, Table 2). An additional 45 sites within La Grange Reach were sampled prior to placement but were dropped from analysis because placement in past years could not be confirmed (Table. 1).

The LTRMP sampled main channel shoreline habitats with several gears from 1993-2004. These gears included day electrofishing, night electrofishing, hoop netting (both large and small mesh), minnow fyke netting, and seining. Night electrofishing and seining were dropped from program-wide use in 2002 thus data from these gears only exist from 1993-2002 (Ickes and Burkhardt 2002). Catches for large and small hoop nets, which are fished in a paired fashion, were combined as "hoop netting" for assemblage analysis for increased sample sizes but analyzed as separate gears for gear specific comparisons of catch rates.

Data from the two sample reaches were not combined for analysis because previous studies have indicated different fish communities are present in each reach (Chick et al. 2005). Reach-wide methodologies are being developed to combine multiple gears for statistical analysis (Chick et al. 2005). However, gear-effort, which is consistent within a reach between years, is not balanced between gears or spatially within reaches after further stratifying the data *post-hoc* by placement areas. Prior studies have also documented gear-specific differences in fish assemblage collections of the UMRS, suggesting that the catch data should not be indiscriminately combined (Chick et al. 2005). Therefore we will look at each sample reach independently, and perform analysis based upon gear to avoid this bias.

Catch rates were standardized as total fish collected at one site and are expressed as follows: Day and night electrofishing (fish/run or fish/15 minutes); hoop netting (fish/set); minnow fyke netting (fish/set); seining (fish/ [2] hauls).

Integrating fish and dredging data

Fish sites sampled from 1993 – 2004 were identified using ArcView 3.3 and classified based upon whether or not dredged material was placed on the bank where the gear was fished. A buffer (80 m for La Grange Reach, and 160 m for Pool 13) around dredged placement locations was used in ArcView to properly assign shoreline sampling data as placed or un-placed. This buffer area was needed to correct for methods that assigns coordinates for fish sites (center of a grid), water level at time of sampling, and variation in base map water/shore location. The buffering was needed to account for proper shoreline classification but did not buffer either upstream or downstream of placement locations in that records were visually checked to insure sites were properly identified with placement records. The LTRMP sites that were within placement locations were identified as placed sites and those data points that fell outside these placement areas were considered not impacted or un-placed sites.

Two datasets were created from the placement and fish site locations. First, one depicting historical placement looked at all fish sites and the proximity of any placement of over 60 years worth of data, disregarding year. All of these sites were depicted as placed sites, and those areas not in proximity of a placement were noted as unplaced sites. Historic data sets were created for both reaches. Second, a dataset was created that depicted modern placement. Within this dataset, the year of the placement was recorded for the time period 1990 – 2003 and only these years were used to designate whether the fish collection occurred on a placed or unplaced site. Fish sites that occurred on a placed site within the GIS but were actually sampled before any modern placement (1990-2004) occurred were rare, but removed from the analysis. Modern data sets were created for La Grange Reach only, due to lack of modern placement sites in Pool 13 the entire historical data set is used for analysis. In general, the two datasets can be described as modern and historical.

Analytical methodology

Analysis of sediment type at the fish sites was made as a pre-cursor to fish data analysis to assess whether the physical characteristics were different between placed or unplaced locations. Physical aspects of the fish collection site are taken prior to deploying the sampling gear at each site (Gutreuter et al. 1995). This includes a categorical value referring to the predominant substrate type, one of four values is recorded for any one site (1-silt, 2-silt/clay/little sand, 3-sand/ mostly sand, 4-gravel/ rock/ hard clay; Gutreuter et al. 1995). Because these values are ordinal a non-parametric approach (Wilcoxen test) was used (Pegg et al. 1999). Results were declared significant at $P \leq 0.05$.

Although our analysis was performed *post-hoc* we felt that a summary of statistical power based upon our available data would provide valuable insight into our ability to detect differences. These estimates would also provide a framework for possible future study design. Power has to be calculated for individual gears due to gear specific differences in catch rates and annual differences in effort. Power analysis used historical placement locations in site selection of Pool 13 fish catch data and modern placement locations in site selection of La Grange Reach fish catch data for reasons stated above. Power analyses were calculated for the most common species and species of interest in each reach by gear using UCLA Online Statistical Calculator (UCLA 2005).

Descriptive statistics include catch rates and standard errors for species by gear for each reach. Using SAS® software (SAS® Institute Inc. 1999), a t-test was performed to test for significant differences between mean catch rates for placed and unplaced sites by species for each gear using the modern placement in La Grange Reach and historical placement in Pool 13. Years were pooled for analysis for both sample areas to improve sample sizes. A Bonferonni correction was made to account for multiple comparisons (Manly 2001).

Further analysis of the entire fish assemblage was performed with an Analysis of Similarity (ANOSIM) test for differences in placed versus un-placed assemblages. The ANOSIM technique is a multivariate approach somewhat analogous in concept to univariate analysis of variance (ANOVA). However, the ANOSIM results are determined using a series of randomized simulations to generate test statistics rather than identifying critical thresholds from a predetermined distribution as is the case with ANOVA. For ANOSIM analyses, the Global R indicates the relative dis-similarity among testable units where values close to 1.0 indicate communities have little or no overlap and values near 0.0 suggest complete community overlap. These analyses were further corroborated using non-metric multidimensional scaling (NMDS) using Primer ver. 5, software (Primer-E Ltd 2001). The NMDS approach plots data points relative to each other thereby graphically illustrating the similarity or dis-similarity of given data points based on the distances each point is from the others. These data points can sometimes exceed the ability of a two-dimensional plot to accurately represent the relation of all data points. Therefore, the data points are forced or "stressed" into the plot. Stress levels below 2.0 are generally considered acceptable to provide accurate representations on the NMDS plots (Primer-E, Ltd. 2001). However as stress levels exceed values of 2.0, caution should be used when identifying community differences solely from the NMDS plots because the plot may not reflect the overall relation among data points. Fish assemblage (or community) differences have been identified by other researchers using these methods throughout the UMRS based upon spatial and environmental parameters. These multivariate methods may give further insight into assemblage relations that univariate methods alone cannot provide (Chick et al. 2005, Barko et al. 2005, Schramm 2004, Clarke 1993, Clarke and Warwick 1994).

First, analyses were performed using presence-absence for all gears combined by reach and placement status. The presence-absence approach allows all species to contribute equally to the analytical results (Clarke 1993). For assemblage analysis using presence/absence data, ANOSIM and NMDS were conducted using Euclidean distance. Next, we tested for differences in assemblages using gear-specific catch data and fish abundances based on a Bray-Curtis similarity index (Clarke 1993, Bray and Curtis 1957). Data were fourth root transformed for both data types to moderate the influence of extreme abundances (Clarke 1993). The ANOSIM results are declared significant at P <

0.05. Plots using NMDS were assessed visually for differences between fish assemblage compositions and deemed significant with the results of ANOSIM. Significant results were analyzed using the SIMPER procedure to determine which species within these fish assemblages are contributing to assemblage differences (Primer-E Ltd 2001).

Results

The LTRMP has collected almost half a million fish in the main channel habitats of Pool 13 and La Grange Reach from 1993-2004 (Table 3). Overall, catches for these two reaches are quite diverse with over 92 species and 6 hybrids being collected.

Sediment analysis

The median sediment type did not differ between placed and un-placed sites for the historical placement data. From the La Grange Reach, over 65% of the historical sites identified as placed sites had Sand/Mostly sand substrates with un-placed sites having just over 25% Sand/Mostly sand substrates both with median values of 3 which were not significantly different ($P = 0.0783$). The La Grange Reach modern sites median values of 3 (Sand/Mostly sand) were also not significantly different ($P = 0.2206$). Within the sites of Pool 13 (historically placed only) placed sites had median substrate values of 3 (Sand/Mostly sand) while the un-placed sites had median substrate values of 2 (Silt/Clay/Little sand). These values were significantly different ($P = 0.0001$).

Power analysis

Power analysis suggests that there is little overall power to detect change in abundance for most species between placement and unplaced sites, but was adequate for a select few species. A list of the most common species as well as those of special interest and power values (P) for each pool by gear are found in Appendix A. In La Grange Reach, day electrofishing has good power for western mosquitofish *Gambusia affinis* (P = 1.000) and black crappie *Pomoxis nigromaculatus* (P = 0.870; Table A.1). Similarly we have relatively poor power for gizzard shad *Dorosoma cepedianum* (P = 0.198) and bluegill *Lepomis macrochirus* (P = 0.065; Table A.1).

La Grange Reach species analysis

Within La Grange Reach, 75 species and 5 hybrids were collected from 1,314 sites identified in the main channel border habitat with 261 (20%) having historical evidence of placement activity and 92 (7.0%) having modern placement activity (Table 4).

A total of 8% of the day electrofishing sites, 6% of the large hoop net sites, 5% of the small hoop net sites, 7% of the minnow fyke net sites, and 10% of the seine sites were sampled on modern placement sites (Table 4).

A total of 70 taxa were collected in day electrofishing of La Grange Reach. Of these, 41 taxa were more abundant on un-placed sites (24 taxa were not collected at all on placement sites). There were no species collected by day electrofishing on placement sites only (Table 4).

A total of 26 taxa were collected in large hoop netting of La Grange Reach. Of these, 18 taxa were more abundant on un-placed sites (11 taxa were not collected at all on placement sites). There were no species collected by large hoop netting on placement sites only (Table 4).

A total of 71 taxa were collected in minnow fyke netting of La Grange Reach. Of these, 44 taxa were more abundant on un-placed sites (25 taxa were not collected at all on placement sites). There were two taxa collected by minnow fyke netting on placement sites only (Table 4).

A total of 53 taxa were collected in seining of La Grange Reach. Of these, 37 taxa were more abundant on un-placed sites (26 taxa were not collected at all on placement sites). There were two taxa collected by seining on placement sites only (Table 4).

Several species were found to have significantly lower catch rates on modern placement sites: black buffalo *Ictiobus niger*, flathead catfish *Pylodictis olivaris*, and longnose gar *Lepisosteus osseus* (day electrofishing; $P < 0.0007$); brown bullhead *Ameiurus nebulosus* and flathead catfish (large hoop netting, $P < 0.002$); common carp *Cyprinus carpio* (small hoop netting, $P < 0.003$); river carpsucker *Carpiodes carpio* (minnow fyke netting, $P < 0.002$); and bullhead minnow *Pimephales vigilax*, golden shiner *Notemigonus* *crysoleucas*, and silverband shiner *Notropis shumardi* (seining, $P < 0.002$). There were no taxa that exhibited significantly lower catches on the modern un-placed sites (Table 4).

Pool 13 species analysis

Within Pool 13, 72 species and 1 hybrid were collected. A total of 687 sites were identified in the main channel border habitat with 188 (27%) having historical evidence of placement activity and only 7 (1%) having modern placement activity (Table 5).

A total of 28.7% of the day electrofishing sites, 25% of the night electrofishing sites, 24% of the large hoop net sites, 23% of the small hoop net sites, 34% of the minnow fyke net sites, and 28% of the seine sites were sampled on historical placement sites (Table 5).

A total of 57 taxa were collected in day electrofishing of Pool 13. Of these, 27 taxa were more abundant on un-placed sites (7 taxa were not collected at all on placement sites). There were 5 taxa collected by day electrofishing on placement sites only (Table 5).

A total of 52 taxa were collected in night electrofishing of Pool 13. Of these, 25 taxa were more abundant on un-placed sites (8 taxa were not collected at all on placement sites). There were 3 taxa collected by night electrofishing on placement sites only (Table 5).

A total of 20 taxa were collected in large hoop netting of Pool 13. Of these, 15 taxa were more abundant on un-placed sites (8 taxa were not collected at all on placement sites). There were 1 taxa collected by large hoop netting on placement sites only (Table 5).

A total of 18 taxa were collected in small hoop netting of Pool 13. Of these, 9 taxa were more abundant on un-placed sites (5 taxa were not collected at all on placement sites). There were 2 taxa collected by small hoop netting on placement sites only (Table 5).

A total of 58 taxa were collected in minnow fyke netting of Pool 13. Of these, 36 taxa were more abundant on un-placed sites (13 taxa were not collected at all on placement sites). There were 3 taxa collected by minnow fyke netting on placement sites only (Table 5).

A total of 52 taxa were collected in seining of Pool 13. Of these, 33 taxa were more abundant on un-placed sites (15 taxa were not collected at all on placement sites). There were no taxa collected by seining on placement sites only (Table 5).

From Pool 13, there were no significant differences of catch rates detected using historical placement data for any taxa or gear combination (Table 5).

La Grange Reach fish assemblage

The ANOSIM of reach wide species richness based upon presence-absence data from all gears combined in La Grange Reach shows significantly different fish communities between placed and unplaced sites ($P = 0.0003$). However the Global R (0.062) suggests differences between the communities is slight. The NMDS ordination plot supports this finding in that there is no visual evidence of a separation between the two communities (Figure 2).

The ANOSIM results suggest that the fish communities on placed and un-placed sites sampled by day electrofishing are significantly different ($P = 0.0017$). However the global R ($R = 0.068$) suggests that these fish communities show relatively little separation between subgroups. Differences in species abundances contributing most (up to 50%) to the dissimilarity include gizzard shad, emerald shiner *Notropis atherinoides,* freshwater drum *Aplodinotus grunniens,* threadfin shad *Dorosoma petenense,* skipjack herring *Alosa chrysochloris*, white bass *Morone chrysops,* and white crappie *Pomoxis annularis* (Table 6). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 3).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by hoop netting ($P = 0.515$, $R < 0.01$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include common carp and channel catfish *Ictalurus punctatus* (Table 7). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 4).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by minnow fyke netting ($P = 0.577$, $R < 0.01$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include gizzard shad, emerald shiner, white bass, freshwater drum, bluegill, channel catfish, and white crappie (Table 8). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 5).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by seining ($P = 0.488$, $R = 0.002$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include gizzard shad, emerald shiner, white bass, threadfin shad, and freshwater drum (Table 9). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 6).

Pool 13 Fish Assemblage

The ANOSIM of reach wide species richness based upon presence-absence data from all gears combined in Pool 13 shows no significant differences in fish communities between placed and unplaced sites ($P = 0.204$, Global $R = 0.016$). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 7).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by day electrofishing ($P = 0.704$, $R < 0.001$). Differences in species contributing most (up to 50%) to the dissimilarity include gizzard shad, emerald shiner, river shiner *Notropis blennius*, largemouth bass *Micropterus salmoides*, spotfin shiner *Cyprinella spiloptera*, bluegill, freshwater drum, white bass, common carp, and shorthead redhorse *Moxostoma macrolepidotum* (Table 10). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 8).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by night electrofishing ($P = 0.151$, $R < 0.092$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include freshwater drum, common carp, gizzard shad, emerald shiner, sauger *Stizostedion canadense*, and white bass (Table 11). Although, the NMDS ordination plot suggests slight visual evidence of a possible relationship, the ANOSIM does not support it (Figure 9).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by hoop netting ($P = 0.975$, $R < 0.001$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include channel catfish and smallmouth buffalo *Ictiobus bubalus* (Table 12). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 10).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by minnow fyke netting ($P = 0.203$, $R < 0.025$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include mimic shiner *Notropis volucellus*, river shiner, emerald shiner, bluegill, channel shiner *Notropis wickliffi*, and bullhead minnow (Table 13). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 11).

The ANOSIM results suggest no significant differences between fish communities on placed and un-placed sites sampled by seining ($P = 0.904$, $R = 0.001$). Differences in species abundances contributing most (up to 50%) to the dissimilarity include mimic shiner, channel shiner, river shiner, spotfin shiner, and white bass (Table 14). The NMDS ordination plot does not give substantial visual evidence of a separation between the two communities (Figure 12).

Discussion

Our results suggest that few overall changes or long term impacts of fish assemblages due to dredged material placement activity can be detected using the LTRMP fisheries data for either the modern or historical placement data from La Grange Reach, IWW or Pool 13, Mississippi River using these techniques. The lack of significant differences is not totally surprising. Intense site specific research has indicated the majority of species collected did not show a significant response over a short time frame to placement, with only a few minnow species (red shiner *Cyprinella lutrensis*, Mississippi silvery minnow *Hybognathus nuchalis*, and river shiner) showing a response (Caswell et al. 2004). Of the species showing significant differences from our data, four of the nine are minnows (Cyprinidae), two are suckers (Catostomidae), which feed in association with the substrate, two are catfish species (Ictaluridae) which live in close proximity with the substrate, and one gar (Lepisosteidae) known to feed upon minnows as well as gizzard shad (Pflieger 1997). Caswell et al. (2004) speculate that declines in observed abundances of the three minnow species may be from declines in available food sources at placed sites. These food sources are likely macroinvertebrates within the substrate. In that light, macroinvertebrates (potential fish food) have been found to be impacted at placement sites and research suggests that recovery of macroinvertebrates is not evident within the first year post-placement (Koel and Stevenson 2002, Flint 1979). One study investigating bacterial response noted recovery in five years (Bireley and Buck 1975). These factors may contribute to the observed decreased abundance on placement sites in La Grange Reach, yet at the temporal scale, may overlook some of the subtle changes. In fact, some sites may have been recovering from placement activity when sampled by the LTRMP. Likely, a whole range of recently placed sites as well as those that may have recovered were all present within the placed site stratum. Unfortunately, the design of LTRMP sampling does not partition the main channel habitat or other habitats based upon anthropogenic changes (dredging activity). Therefore, the placed and unplaced sites used for analysis occur in the relative proportion at which they exist within the pool. Creating the link between bacterial or macroinvertebrate communities and fisheries response is not straight forward due to behavioral and sublethal effects (Greene 2002).

Site specific research will be valuable to detect some of these less obvious effects but reach-wide effects may continue to be important as larger river fish, in particular, use multiple habitats during their lives. Galat and Zweimüller (2001) suggest the lack of information on habitat requirements of large river fishes is "the most serious impediment to understanding and managing" them. Future research on the diet of main channel fishes may aid in finding the less obvious effects of habitat modifications due to dredged material placement.

The main channels of large rivers are increasingly described as important habitats for aquatic organisms (Detmers et al. 2001, Galat and Zweimüller 2001). Also, it is likely that for fish, invertebrates within the substrates as well as within the water column are very important during the time they spend in this habitat. Galat and Zweimüller (2001) suggest that the loss of habitat diversity within main channels contribute to loss of fishes that depend on these flowing environs. These habitats make up a majority of available habitats within the UMRS. From the six study reaches of the LTRMP, total main channel habitats account for 10-79% of the total aquatic surface area within a given reach (Gutreuter 1997).

A further limitation to this analysis, particularly in La Grange Reach, is the possibility that dredging, pollution, or other combinations of anthropogenic effects changed the fish assemblage significantly to the point that we cannot currently detect minute changes due to dredging alone. Within the IWW, there is a history of man's effects on the fish assemblage (Pegg and McClelland 2004, Mills et al 1966) since the early 1900's with some of those communities recovering just recently as evidenced by the increases in sport and forage fishes and the decline of rough fish (common carp and goldfish *Carassius auratus*) most likely in response to the Clean Water Acts of the 1970's (Pegg and McClelland 2004).

Additional limitations in data analysis are pointed out within the power analysis. This analysis suggests that very few of the species collected have been sampled with significant power to detect changes. Although there is no fault in the monitoring program, the program was not designed to look at the effects of dredging on specific organisms. Future research should make plans stratifying newly taken samples by dredged material placement treatments to reach a desired detection level using LTRMP or similar methods.

It is encouraging that blatant differences throughout placed and un-placed sites do not occur at the level which LTRMP can detect them either at a species specific or fish assemblage level. It would be prudent to examine the other LTRMP reaches where various levels of placement exist. From 1980-1995, dredging within the reaches were as follows: Pool 4 < 350,000 tons/year, Pool 8 < 100,000 tons/year, Pool 13 < 80, 000 tons/year, Pool 26 > 750,000 tons/year, La Grange Reach > 280,000 tons/year (West Consultants, Inc. 2000). It is evident from historical dredging data, and paucity of Pool 13 modern placement sites, that there is a gradient of dredging activities from Pool 13 to Pool 26. Future investigations in the lower UMRS should include additional information that can be gleaned from areas that have relatively high dredging activity (e.g., Pool 26).

With improvements being planned within the navigation systems of the UMRS it is possible that increased traffic and maintenance dredging will occur. Continued diligence to recognize and identify the effects of dredged material placement can assist in the management of large river systems and aid in the conservation of large river fishes.

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Table 1. Number of fish sites by gear sampled by the Long Term Resource Monitoring Program and status of modern dredge material placement in La Grange Reach, IWW, 1993-2004.

gear	Placed sites	Un-placed sites	Unconfirmed	Total sites
Day electrofishing	30	351	12	393
Large hoop netting	16	236	4	256
Small hoop netting	13	238	5	256
Minnow fyke netting	19	239	14	272
Seining	14	125	10	149
Grand Total	92	1189	45	1326

Table 2. Number of fish sites by gear sampled by the Long Term Resource Monitoring Program and status of historical dredge material placement in Pool 13, Mississippi River, 1993-2004.

gear	Placed sites	Un-placed sites	Total sites
Day electrofishing	39	97	136
Night electrofishing	10	40	50
Large hoop netting	28	87	115
Small hoop netting	23	77	100
Minnow fyke netting	44	86	130
Seining	44	112	156
Grand Total	188	499	687

Table 3. Total fish collected by the Long Term Resource Monitoring Program, from Pool 13, Mississippi River (MR) and La Grange Reach, Illinois Waterway (IWW), main channel border from select gears, 1993-2004. Gears = Day electrofishing, Night electrofishing, Large hoop netting, Small hoop netting, Minnow fyke netting, Seining.

CommonName	GenusSpecies	Pool 13 MR.	La Grange Reach IWW
Chestnut lamprey	*Ichthyomyzon castaneus*	1	1
Silver lamprey	*Ichthyomyzon unicuspis*	8	–
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	1	–
Spotted gar	*Lepisosteus oculatus*	–	5
Longnose gar	*Lepisosteus osseus*	55	51
Shortnose gar	*Lepisosteus platostomus*	91	380
Bowfin	*Amia calva*	13	5
Goldeye	*Hiodon alosoides*	–	24
Mooneye	*Hiodon tergisus*	62	–
American eel	*Anguilla rostrata*	–	1
Skipjack herring	*Alosa chrysochloris*	–	2,345
Gizzard shad	*Dorosoma cepedianum*	2,663	242,246
Threadfin shad	*Dorosoma petenense*	–	15,966
Unidentified Clupeid	*Clupeidae*	–	4,527
Central stoneroller	*Campostoma anomalum*	–	51
Goldfish	*Carassius auratus*	–	96
Grass carp	*Ctenopharyngodon idella*	–	317
Red shiner	*Cyprinella lutrensis*	–	417
Spotfin shiner	*Cyprinella spiloptera*	1,079	–
Common carp	*Cyprinus carpio*	1,915	8,855
Carp x goldfish hybrid	*Cyprinus carpio x auratus*	–	27
Mississippi silvery minnow	*Hybognathus nuchalis*	4	–
Silver carp	*Hypopthalmichthys molitrix*	–	145
Bighead carp	*Hypopthalmichthys nobilis*	–	480
Speckled chub	*Macrhybopsis aestivalis*	9	–
Silver chub	*Macrhybopsis storeriana*	396	228
Golden shiner	*Notemigonus crysoleucas*	47	193
Emerald shiner	*Notropis atherinoides*	32,613	36,354
River shiner	*Notropis blennius*	14,861	74
Spottail shiner	*Notropis hudsonius*	241	190
Silverband shiner	*Notropis shumardi*	–	468
Sand shiner	*Notropis stramineus*	38	123
Weed shiner	*Notropis texanus*	10	–
Mimic shiner	*Notropis volucellus*	42,557	–
Channel shiner	*Notropis wickliffi*	4,757	–
Pugnose minnow	*Opsopoeodus emiliae*	73	–
Suckermouth minnow	*Phenacobius mirabilis*	4	5
Bluntnose minnow	*Pimephales notatus*	46	418
Fathead minnow	*Pimephales promelas*	5	9
Bullhead minnow	*Pimephales vigilax*	1,217	497
Blacknose dace	*Rhinichthys atratulus*	–	2
Creek chub	*Semotilus atromaculatus*	1	22
River carpsucker	*Carpiodes carpio*	1,386	345

Table 3. Continued.

CommonName	GenusSpecies	Pool 13 MR.	La Grange Reach IWW
Quillback	*Carpiodes cyprinus*	78	11
Highfin carpsucker	*Carpiodes velifer*	166	3
White sucker	*Catostomus commersoni*	1	1
Blue sucker	*Cycleptus elongatus*	3	1
Northern hog sucker	*Hypentelium nigricans*	1	2
Smallmouth buffalo	*Ictiobus bubalus*	551	4,208
Bigmouth buffalo	*Ictiobus cyprinellus*	70	412
Black buffalo	*Ictiobus niger*	9	59
Spotted sucker	*Minytrema melanops*	3	–
Silver redhorse	*Moxostoma anisurum*	7	5
Golden redhorse	*Moxostoma erythrurum*	37	19
Shorthead redhorse	*Moxostoma macrolepidotum*	502	118
Unidentified sucker	*Unidentified Catostomidae*	73	1,875
Black bullhead	*Ameiurus melas*	9	2,106
Yellow bullhead	*Ameiurus natalis*	1	55
Brown bullhead	*Ameiurus nebulosus*	–	19
Blue catfish	*Ictalurus furcatus*	–	5
Channel catfish	*Ictalurus punctatus*	1,695	6,863
Unidentified catfish	*Ictalurus sp.*	–	2
Stonecat	*Noturus flavus*	2	2
Tadpole madtom	*Noturus gyrinus*	36	2
Freckled madtom	*Noturus nocturnus*	–	1
Flathead catfish	*Pylodictis olivaris*	126	200
Grass pickerel	*Esox americanus vermiculatus*	1	1
Northern pike	*Esox lucius*	13	–
Tiger muskellunge	*Esox masquinongy x lucius*	–	1
Blackstripe topminnow	*Fundulus notatus*	–	21
Western mosquitofish	*Gambusia affinis*	–	1,537
Brook silverside	*Labidesthes sicculus*	295	57
Brook stickleback	*Culaea inconstans*	3	–
White perch	*Morone americana*	–	11
White bass	*Morone chrysops*	1,582	9,160
Yellow bass	*Morone mississippiensis*	9	64
White perch x yellow bass	*Morone americana x miss.*	–	6
Striped x white bass	*Morone saxatilis x chrysops*	–	5
Rock bass	*Ambloplites rupestris*	41	1
Green sunfish	*Lepomis cyanellus*	10	65
Pumpkinseed	*Lepomis gibbosus*	49	–
Warmouth	*Lepomis gulosus*	5	15
Orangespotted sunfish	*Lepomis humilis*	146	58
Bluegill	*Lepomis macrochirus*	2,684	5,271
Redear sunfish	*Lepomis microlophus*	–	2
Green x bluegill sunfish	*Lepomis cyanellus x macrochirus*	–	9
Bluegill x orangespotted sunfish	*Lepomis macrochirus x humilis*	1	–
Smallmouth bass	*Micropterus dolomieu*	98	8
Largemouth bass	*Micropterus salmoides*	842	588
White crappie	*Pomoxis annularis*	40	971

Table 3. Continued.

CommonName	GenusSpecies	Pool 13 MR.	La Grange Reach IWW
Black crappie	*Pomoxis nigromaculatus*	87	533
Western sand darter	*Ammocrypta clara*	24	–
Mud darter	*Etheostoma asprigene*	170	82
Johnny darter	*Etheostoma nigrum*	170	11
Yellow perch	*Perca flavescens*	12	–
Logperch	*Percina caprodes*	163	138
Slenderhead darter	*Percina phoxocephala*	8	8
River darter	*Percina shumardi*	275	–
Sauger	*Sander canadense*	527	617
Walleye	*Sander vitreus*	237	19
Freshwater drum	*Aplodinotus grunniens*	2,574	7,922
Total catch		117,589	358,017

Table 4. Sampling effort, mean catch per effort with *standard error* below for catches by species for fish collected in main channel border habitat, La Grange Reach, Illinois Waterway 1993-2004. Significant differences in mean catch per effort are denoted with mean catch per effort values undelined. Values are significant at the P < 0.05/n (Manly 2001).

	Gear:	Day electrofishing		Large hoop netting		Small hoop netting		Minnow fyke netting		Seining	
	effort (n):	30	351	16	236	13	238	19	239	14	125
Common name	Genus species	P	U	P	U	P	U	P	U	P	U
Chestnut lamprey	*Ichthyomyzon castaneus*	-	0.0028	-	-	-	-	-	-	-	-
		-	*0.0028*	-	-	-	-	-	-	-	-
Spotted gar	*Lepisosteus oculatus*	-	0.0057	-	-	-	-	-	0.0126	-	-
		-	*0.0040*	-	-	-	-	-	*0.0072*	-	-
Longnose gar	*Lepisosteus osseus*	-	0.0912	-	-	-	-	-	0.0544	-	0.0240
		-	*0.0237*	-	-	-	-	-	*0.0179*	-	*0.0178*
Shortnose gar	*Lepisosteus platostomus*	0.2000	0.2507	-	0.0169	-	0.0042	1.2105	0.9414	-	0.0640
		0.1006	*0.0359*	-	*0.0120*	-	*0.0042*	*0.6379*	*0.2455*	-	*0.0247*
Bowfin	*Amia calva*	-	0.0085	-	-	-	-	-	0.0084	-	-
		-	*0.0049*	-	-	-	-	-	*0.0084*	-	-
Goldeye	*Hiodon alosoides*	0.0333	0.0541	-	-	-	-	-	-	-	0.0080
		0.0333	*0.0180*	-	-	-	-	-	-	-	*0.0080*
American eel	*Anguilla rostrata*	-	-	-	-	-	-	-	0.0042	-	-
		-	-	-	-	-	-	-	*0.2909*	-	-
Skipjack herring	*Alosa chrysochloris*	5.3000	4.5470	-	-	-	-	0.1053	0.2762	0.5000	3.4000
		2.9420	*0.9529*	-	-	-	-	*0.0723*	*0.0990*	*0.2514*	*1.7374*
Gizzard shad	*Dorosoma cepedianum*	135.9667	245.7436	0.0625	0.2797	0.0769	0.0588	1772.2632	400.9498	173.3571	135.3680
		68.4542	*69.7512*	*0.0625*	*0.0480*	*0.0769*	*0.0318*	*1515.6700*	*167.4580*	*113.5380*	*38.6168*
Threadfin shad	*Dorosoma petenense*	6.2000	3.5926	-	-	-	-	2.9474	55.5941	0.5714	8.9440
		2.7301	*0.5872*	-	-	-	-	*1.6374*	*43.0799*	*0.0310*	*4.2778*
Unidentified Clupeid	*Clupeidae*	0.2000	0.3447	-	-	-	-	32.7368	15.8075	-	-
		0.2000	*0.2303*	-	-	-	-	*32.7368*	*11.9328*	-	-
Central stoneroller	*Campostoma anomalum*	-	0.0057	-	-	-	-	0.6316	0.1130	-	-
		-	*0.0040*	-	-	-	-	*0.5784*	*0.0485*	-	*0.0080*
Goldfish	*Carassius auratus*	0.4667	0.1168	-	-	-	-	0.0526	0.0167	0.0714	0.0160
		0.4335	*0.0283*	-	-	-	-	*0.0526*	*0.0083*	*0.0714*	*0.0113*
Grass carp	*Ctenopharyngodon idella*	0.7000	0.1026	-	0.0254	-	0.0168	0.2105	0.8410	-	0.1600
		0.3900	*0.0271*	-	*0.0119*	-	*0.0103*	*0.2105*	*0.6767*	-	*0.0806*
Red shiner	*Cyprinella lutrensis*	0.2333	0.0940	-	-	-	-	2.3158	1.0084	0.2857	0.6000
		0.1240	*0.0312*	-	-	-	-	*1.2140*	*0.2687*	*0.2857*	*0.2486*
Common carp	*Cyprinus carpio*	4.2000	5.5584	6.0000	11.5254	2.6923	7.5882	1.0000	4.7322	0.5000	0.1600
		1.0574	*0.4070*	*2.4899*	*1.3497*	*1.0704*	*0.6357*	*0.5514*	*2.6770*	*0.3593*	*0.0446*
Carp x goldfish hybrid	*Cyprinus carpio x auratus*	-	0.0513	-	0.0042	-	0.0042	-	-	0.0714	0.0080
		-	*0.0154*	-	*0.0042*	-	*0.0042*	-	-	*0.0714*	*0.0080*
Silver carp	*Hypopthalmichthys molitrix*	0.1000	0.3704	-	0.0085	-	-	-	0.0335	-	-
		0.0557	*0.1339*	-	*0.0060*	-	-	-	*0.0186*	-	-
Bighead carp	*Hypopthalmichthys nobilis*	0.3333	0.1083	0.1250	0.7542	-	0.0084	1.8421	0.4770	-	0.5600
		0.3007	*0.0524*	*0.0854*	*0.2567*	-	*0.0059*	*1.3600*	*0.2910*	-	*0.3238*
Silver chub	*Macrhybopsis storeriana*	0.2667	0.1396	-	-	-	0.0126	0.2632	0.2008	0.4286	0.6480
		0.1262	*0.0288*	-	-	-	*0.0072*	*0.1289*	*0.0452*	*0.2912*	*0.1643*
Golden shiner	*Notemigonus crysaleucas*	-	0.0399	-	-	-	-	3.0526	0.4351	-	0.1200
		-	*0.0105*	-	-	-	-	*2.5734*	*0.1435*	-	*0.0352*
Emerald shiner	*Notropis atherinoides*	18.5333	9.4444	-	-	-	-	604.5263	58.2218	37.2857	43.2880
		10.6821	*2.0493*	-	-	-	-	*351.1040*	*9.5645*	*17.4230*	*13.2067*
River shiner	*Notropis blennius*	0.0333	0.0114	-	-	-	-	0.1053	0.2469	0.1429	0.0320
		0.0333	*0.0057*	-	-	-	-	*0.1053*	*0.1246*	*0.1429*	*0.0158*
Spottail shiner	*Notropis hudsonius*	-	0.0228	-	-	-	-	0.7895	0.2008	0.1429	0.3840
		-	*0.0080*	-	-	-	-	*0.4088*	*0.0919*	*0.0971*	*0.2158*
Silverband shiner	*Notropis shumardi*	0.1667	0.1595	-	-	-	-	1.8947	0.8912	-	0.4960
		0.1081	*0.0444*	-	-	-	-	*1.4263*	*0.1948*	-	*0.1237*
Sand shiner	*Notropis stramineus*	-	-	-	-	-	-	0.1053	0.0628	-	0.0800
		-	-	-	-	-	-	*0.0723*	*0.0259*	-	*0.0477*
Suckermouth minnow	*Phenacobius mirabilis*	-	0.0028	-	-	-	-	-	0.0042	-	0.0160
		-	*0.0028*	-	-	-	-	-	*0.0042*	-	*0.0113*
Bluntnose minnow	*Pimephales notatus*	-	0.0085	-	-	-	-	0.1053	0.3598	0.0714	0.0640
		-	*0.0064*	-	-	-	-	*0.0723*	*0.1504*	*0.0714*	*0.0295*
Bullhead minnow	*Pimephales vigilax*	1.3333	0.1425	-	-	-	-	1.5789	1.1213	-	0.8320
		1.2320	*0.0316*	-	-	-	-	*0.6133*	*0.2592*	-	*0.2041*
Fathead minnow	*Pimephales promelas*	-	-	-	-	-	-	0.3158	0.0042	-	0.0160
		-	-	-	-	-	-	*0.2170*	*0.0042*	-	*0.0113*
Blacknose dace	*Rhinichthys atratulus*	-	-	-	-	-	-	-	0.0042	-	-
		-	-	-	-	-	-	-	*0.0042*	-	-
Creek chub	*Semotilus atromaculatus*	-	0.0057	-	-	-	-	-	0.0251	-	-
		-	*0.0057*	-	-	-	-	-	*0.0177*	-	-
River carpsucker	*Carpiodes carpio*	1.4333	0.5185	0.0625	0.2839	-	-	-	0.0669	0.1429	0.1360
		0.6246	*0.0750*	*0.0625*	*0.0981*	-	-	-	*0.0209*	*0.0971*	*0.0445*
Quillback	*Carpiodes cyprinus*	0.0333	0.0142	0.0625	0.0085	-	-	-	-	-	0.0080
		0.0333	*0.0063*	*0.0625*	*0.0060*	-	-	-	-	-	*0.0080*
Highfin carpsucker	*Carpiodes velifer*	-	0.0028	-	0.0042	-	-	-	-	-	0.0080
		-	*0.0028*	-	*0.0042*	-	-	-	-	-	*0.0080*
White sucker	*Catostomus commersoni*	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-
Blue sucker	*Cycleptus elongatus*	-	0.0028	-	-	-	-	-	-	-	-
		-	*0.0028*	-	-	-	-	-	-	-	-
Northern hog sucker	*Hypentelium nigricans*	-	0.0028	-	-	-	-	-	-	-	-
		-	*0.0028*	-	-	-	-	-	-	-	-
Smallmouth buffalo	*Ictiobus bubalus*	1.4667	2.2393	7.5625	9.9661	0.1538	0.5294	0.1053	0.1130	0.4286	0.4160
		0.3887	*0.2394*	*3.5023*	*0.9209*	*0.1538*	*0.1046*	*0.0723*	*0.0290*	*0.2020*	*0.0985*
Bigmouth buffalo	*Ictiobus cyprinellus*	0.9667	0.7578	0.0625	0.0169	-	-	-	0.0753	0.4286	0.2560
		0.4485	*0.1246*	*0.0625*	*0.0084*	-	-	-	*0.0342*	*0.4286*	-
Black buffalo	*Ictiobus niger*	-	0.0598	0.1250	0.0975	-	0.0084	-	-	-	-
		-	*0.0156*	*0.0854*	*0.0264*	-	*0.0059*	-	-	-	-
Silver redhorse	*Moxostoma anisurum*	0.0333	0.0028	0.0625	0.0042	-	-	-	-	-	0.0080
		0.0333	*0.0028*	*0.0625*	*0.0042*	-	-	-	-	-	*0.0080*
Golden redhorse	*Moxostoma erythrurum*	0.1333	0.0171	0.0625	0.0085	-	-	0.0526	-	-	0.0080
		0.0926	*0.0106*	*0.0625*	*0.0085*	-	-	*0.0536*	-	-	*0.0080*
Shorthead redhorse	*Moxostoma macrolepidotum*	0.1000	0.1852	0.0625	0.0424	-	0.0042	-	0.0377	-	0.0080
		0.0735	*0.0353*	*0.0625*	*0.0131*	-	*0.0042*	-	*0.0137*	-	*0.0080*
Unidentified sucker	*Unidentified Catostomidae*	0.2667	0.1425	-	-	-	-	3.8947	4.4184	-	0.4160
		0.1585	*0.0598*	-	-	-	-	*2.4433*	*1.3139*	-	*0.1550*
Black bullhead	*Ameiurus melas*	0.0670	0.3930	-	0.0040	-	0.0040	0.1580	8.0880	-	-
		0.6667	*0.2935*	-	*0.0042*	-	*0.0042*	*0.0859*	*5.4482*	-	-
Yellow bullhead	*Ameiurus natalis*	-	0.0085	-	-	-	0.0084	-	0.1967	-	-
		-	*0.0049*	-	-	-	*0.0059*	-	*0.0777*	-	-
Brown bullhead	*Ameiurus nebulosus*	-	0.0057	-	0.0424	-	0.0210	-	0.0084	-	-
		-	*0.0040*	-	*0.0131*	-	*0.0111*	-	*0.0059*	-	-
Blue catfish	*Ictalurus furcatus*	-	-	-	-	-	0.0210	-	-	-	-
		-	-	-	-	-	*0.0151*	-	-	-	-
Channel catfish	*Ictalurus punctatus*	1.0667	1.8889	0.9375	2.2076	6.6154	19.3277	4.3684	2.5481	0.1429	0.8880
		0.4178	*0.1591*	*0.6222*	*0.3456*	*2.9776*	*4.6183*	*2.2970*	*0.3509*	*0.0971*	*0.2628*
Stonecat	*Noturus flavus*	-	-	-	-	-	-	-	0.0042	-	0.0080
		-	-	-	-	-	-	-	*0.0042*	-	*..00800*
Tadpole madtom	*Noturus gyrinus*	-	-	-	-	-	-	-	0.0084	-	-
		-	-	-	-	-	-	-	*0.0059*	-	-
Freckled madtom	*Noturus nocturnus*	-	-	-	-	-	-	-	0.0042	-	-
		-	-	-	-	-	-	-	*0.0042*	-	-

Table 4. Continued.

	Gear:	Day electrofishing		Large hoop netting		Small hoop netting		Minnow fyke netting		Seining	
	effort (n):	30	351	16	236	13	238	19	239	14	125
Common name	Genus species	P	U	P	U	P	U	P	U	P	U
Flathead catfish	*Pylodictis olivaris*	0.0333	0.2479	-	0.1907	0.1538	0.1345	0.0526	0.0460	-	-
		0.0333	*0.0312*	-	*0.0313*	*0.1042*	*0.0244*	*0.0526*	*0.0148*	-	*0.0080*
Unidentified catfish	*Ictalurus sp.*	-	-	-	-	-	-	-	0.0084	-	-
		-	-	-	-	-	-		*0.0084*	-	-
Grass pickerel	*Esox americanus vermiculatus*	-	0.0028	-	-	-	-	-	-	-	-
		-	*0.0028*	-	-	-	-	-	-	-	-
Tiger muskellunge	*Esox masquinongy x lucius*	-	-	-	-	-	-	-	0.0042	-	-
		-	-	-	-	-	-	-	*0.0042*	-	-
Blackstripe topminnow	*Fundulus notatus*	-	0.0057	-	-	-	-	0.0526	0.0544	-	0.0400
		-	*0.0040*	-	-	-	-	*0.0526*	*0.0291*	-	*0.0809*
Western mosquitofish	*Gambusia affinis*	0.1000	0.0741	-	-	-	-	3.1053	5.1423	0.2143	0.5600
		0.1000	*0.0330*	-	-	-	-	*2.2502*	*4.1134*	*0.1547*	*0.1534*
Brook silverside	*Labidesthes sicculus*	0.0333	0.0199	-	-	-	-	0.1053	0.1255	0.1429	0.1200
		0.0333	*0.0085*	-	-	-	-	*0.0723*	*0.0385*	*0.1429*	*0.0477*
White perch	*Morone americana*	0.0667	0.0142	-	-	-	-	-	0.0126	-	-
		0.0463	*0.0063*	-	-	-	-	-	*0.0072*	-	-
White perch x yellow bass	*M. american x miss.*	-	0.0085	-	-	-	0.0042	0.0526	0.0042	-	-
		-	*0.0064*	-	-	-	*0.0042*	*0.0526*	*0.0042*	-	-
White bass	*Morone chrysops*	6.7333	6.6040	0.3125	0.3051	-	0.3067	25.0526	16.9331	4.2857	3.4240
		2.0560	*0.5892*	*0.3125*	*0.1284*	-	*0.1059*	*12.1390*	*2.8013*	*1.5386*	*0.5258*
Yellow bass	*Morone mississippiensis*	0.2667	0.0598	-	-	-	-	0.2105	0.0962	0.0714	-
		0.2346	*0.0180*	-	-	-	-	-	*0.0305*	*0.0714*	-
Striped x white bass	*M. saxatilis x chrysops*	-	0.0114	-	-	-	-	-	0.0042	-	-
		-	*0.0070*	-	-	-	-	-	*0.0042*	-	-
Rock bass	*Ambloplites rupestris*	-	-	-	-	-	-	0.0526	-	-	-
		-	-	-	-	-	-	*0.0526*	-	-	-
Green sunfish	*Lepomis cyanellus*	0.1000	0.0456	-	-	-	0.0042	0.0526	0.1506	0.1429	-
		0.1000	*0.0125*	-	-	-	*0.0042*	*0.0526*	*0.0460*	*0.1429*	-
Warmouth	*Lepomis gulosus*	0.0333	0.0057	-	-	-	-	-	0.0502	-	-
		0.0333	*0.0040*	-	-	-	-	-	*0.0194*	-	-
Orangespotted sunfish	*Lepomis humilis*	0.0333	0.0313	-	-	-	-	0.6316	0.1381	-	0.0080
		0.0333	*0.0142*	-	-	-	-	*0.3079*	*0.0394*	-	*0.0080*
Bluegill	*Lepomis macrochirus*	0.6333	0.7778	-	0.0042	-	0.1891	4.4737	18.2552	1.5714	2.4080
		0.2974	*0.0967*	-	*0.0042*	-	*0.1018*	*2.2728*	*9.8946*	*1.4208*	*1.1148*
Redear sunfish	*Lepomis microlophus*	-	0.0028	-	-	-	-	-	0.0042	-	-
		-	*0.0028*	-	-	-	-	-	*0.0042*	-	-
Green x bluegill sunfish	*L. cyanellus x macrochirus*	-	0.0028	-	-	-	-	0.1053	0.0167	-	-
		-	*0.0028*	-	-	-	-	*0.1053*	*0.0460*	-	-
Smallmouth bass	*Micropterus dolomieu*	-	0.0028	-	-	-	-	0.0526	0.0126	-	0.0240
		-	*0.0028*	-	-	-	-	*0.0526*	*0.0072*	-	*0.0137*
Largemouth bass	*Micropterus salmoides*	1.3667	0.6068	-	-	-	-	0.5263	0.9874	0.2143	0.1760
		0.6635	*0.0653*	-	-	-	-	*0.2796*	*0.2234*	*0.1547*	*0.0426*
White crappie	*Pomoxis annularis*	0.0667	0.1168	-	0.0254	-	0.0168	1.6842	3.4686	-	0.2320
		0.0463	*0.0236*	-	*0.0119*	-	*0.0084*	*0.6669*	*1.2379*	-	*0.1775*
Black crappie	*Pomoxis nigromaculatus*	0.0333	0.1880	0.1875	0.0254	-	0.0252	1.5789	1.5732	-	0.0640
		0.3333	*0.0369*	*0.1875*	*0.0119*	-	*0.0118*	*1.3622*	*0.5474*	-	*0.0220*
Mud darter	*Etheostoma asprigene*	0.0333	0.0057	-	-	-	-	0.1053	0.2427	-	0.0160
		0.0333	*0.0057*	-	-	-	-	*0.1053*	*0.1386*	-	*0.0160*
Johnny darter	*Etheostoma nigrum*	-	-	-	-	-	-	-	0.0377	-	0.0080
		-	-	-	-	-	-	-	*0.0461*	-	*0.0080*
Logperch	*Percina caprodes*	0.0333	0.0655	-	-	-	-	0.2632	0.3264	0.1429	0.0640
		0.0333	*0.0188*	-	-	-	-	*0.2142*	*0.0870*	*0.0971*	*0.0355*
Slenderhead darter	*Percina phoxocephala*	-	0.0028	-	-	-	-	-	0.0126	-	0.0240
		-	*0.0028*	-	-	-	-	-	*0.0093*	-	*0.0137*
Sauger	*Sander canadense*	1.1000	0.7265	-	0.0127	-	0.0168	0.6316	0.4519	0.0714	0.1520
		0.2598	*0.0813*	-	*0.0073*	-	*0.0133*	*0.4727*	*0.0834*	*0.0714*	*0.0441*
Walleye	*Sander vitreus*	0.1667	0.0171	-	-	-	-	-	0.0084	0.0714	0.0080
		0.1667	*0.0121*	-	-	-	-	-	*0.0059*	*0.0714*	*0.0080*
Freshwater drum	*Aplodinotus grunniens*	2.0333	4.1595	0.5625	1.6864	0.0769	0.3950	3.9474	20.7029	0.2143	2.4320
		0.9726	*0.3821*	*0.3023*	*0.2196*	*0.0769*	*0.0683*	*1.6122*	*7.8472*	*0.1547*	*0.8416*

Table 5. Sampling effort, mean catch per effort with *standard error* below for catches by species for fish collected in main channel border habitat, Pool 13, Mississippi River 1993-2004. There were no significant differences in mean catch per effort. Values are significant at the P < 0.05/n (Manly 2001).

	Gear:	Day electrofishing		Night electrofishing		Large hoop netting		Small hoop netting		Minnow fyke netting		Seining	
	effort (n):	39	97	10	40	28	87	23	77	44	86	44	112
Common name	Genus species	P	U	P	U	P	U	P	U	P	U	P	U
Chestnut lamprey	*Ichthyomyzon castaneus*		**0.0103**	-	-	-	-	-	-	-	-	-	-
		-	*0.0103*	-	-	-	-	-	-	-	-	-	-
Silver lamprey	*Ichthyomyzon unicuspis*	**0.0513**	**0.0515**	-	-	-	-	-	-	-	-	-	-
		0.0358	*0.0225*	-	-	-	-	-	-	-	-	-	-
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	-	-	-	-	-	**0.0115**	-	-	-	-	-	-
		-	-	-	-	-	*0.0115*	-	-	-	-	-	-
Longnose gar	*Lepisosteus osseus*	**0.2820**	**0.1237**	**0.9000**	**0.3250**	-	**0.0115**	**0.0435**	-	**0.0682**	**0.0349**	-	**0.0179**
		0.1269	*0.0491*	*0.6904*	*0.0905*	-	*0.0115*	*0.0435*	-	*0.0384*	*0.0199*	-	*0.0126*
Shortnose gar	*Lepisosteus platostomus*	**0.2564**	**0.0722**	-	**0.2500**	-	**0.0115**	**0.0435**	-	**0.2727**	**0.4070**	-	**0.1339**
		0.2315	*0.0302*	-	*0.0930*	-	*0.0115*	*0.0435*	-	*0.1393*	*0.1139*	-	*0.0756*
Bowfin	*Amia calva*	**0.0512**	**0.0103**	**0.1000**	**0.0250**	-	-	-	-	**0.0455**	**0.0698**	-	-
		0.0358	*0.0103*	*0.1000*	*0.0250*	-	-	-	-	*0.0318*	*0.0322*	-	-
Mooneye	*Hiodon tergisus*	**0.2051**	**0.0722**	**2.2000**	**0.4500**	-	-	-	-	-	**0.0116**	**0.1136**	**0.0089**
		0.1609	*0.0335*	*1.7689*	*0.2531*	-	-	-	-	-	*0.0116*	*0.0932*	*0.0089*
Gizzard shad	*Dorosoma cepedianum*	**10.4360**	**14.0620**	**10.0000**	**6.4250**	-	**0.0345**	-	-	**3.8636**	**0.2326**	**1.9545**	**2.2857**
		3.8895	*2.8210*	*5.7542*	*1.5652*	-	*0.0256*	-	-	*3.7478*	*0.1093*	*0.7048*	*0.7503*
Spotfin shiner	*Cyprinella spiloptera*	**1.7179**	**2.5155**	**0.2000**	**0.4250**	-	-	-	-	**2.1364**	**2.4535**	**2.5682**	**2.9554**
		0.4139	*0.5233*	*0.1333*	*0.1675*	-	-	-	-	*0.6208*	*0.6002*	*1.0092*	*1.3427*
Common carp	*Cyprinus carpio*	**10.6923**	**9.2577**	**10.8000**	**6.9500**	**0.0357**	**0.0575**	**0.0435**	**0.0130**	**1.8409**	**1.0465**	**0.0909**	**0.2768**
		1.8696	*0.9702*	*5.0964*	*1.0209*	*0.0357*	*0.0300*	*0.0435*	*0.0130*	*1.5700*	*0.5545*	*0.0546*	*0.1238*
Mississippi silvery minnow	*Hybognathus nuchalis*	**0.0256**	-	-	-	-	-	-	-	**0.0227**	-	**0.0227**	**0.0089**
		0.0256	-	-	-	-	-	-	-	*0.0227*	-	*0.0227*	*0.0089*
Speckled chub	*Macrhybopsis aestivalis*	-	-	-	-	-	-	-	-	-	-	**0.1591**	**0.0179**
		-	-	-	-	-	-	-	-	-	-	*0.0972*	*0.0126*
Silver chub	*Macrhybopsis storeriana*	**0.3077**	**0.6907**	**1.7000**	**1.8250**	-	-	**0.0870**	**0.0649**	**0.0455**	**0.0581**	**1.8636**	**1.1696**
		0.1111	*0.3033*	*0.8699*	*0.5429*	-	-	*0.0600*	*0.0338*	*0.0455*	*0.0254*	*0.9262*	*0.6771*
Golden shiner	*Notemigonus crysoleucas*	-	**0.1237**	**0.2000**	**0.1750**	-	-	-	-	**0.1364**	**0.1395**	-	**0.0714**
		-	*0.0765*	*0.1333*	*0.1126*	-	-	-	-	*0.0697*	*0.0644*	-	*0.0395*
Emerald shiner	*Notropis atherinoides*	**38.6670**	**31.3510**	**3.6000**	**13.3000**	-	-	-	-	**22.3864**	**30.4767**	**107.5455**	**171.0536**
		7.5857	*5.8813*	*0.9568*	*3.9864*	-	-	-	-	*11.3505*	*13.8286*	*32.3244*	*90.7148*
River shiner	*Notropis blennius*	**4.1538**	**4.6701**	**2.1000**	**1.5500**	-	-	-	-	**8.9090**	**34.7093**	**62.7500**	**71.6518**
		1.4711	*0.9127*	*1.2060*	*0.4856*	-	-	-	-	*2.6385*	*11.2567*	*13.9143*	*15.1591*
Spottail shiner	*Notropis hudsonius*	**0.2051**	**0.2474**	**0.2000**	**0.3250**	-	-	-	-	**1.8181**	**0.7209**	**0.4091**	**0.3036**
		0.0913	*0.0842*	*0.1333*	*0.1208*	-	-	-	-	*1.4373*	*0.2294*	*0.2587*	*0.1305*
Sand shiner	*Notropis stramineus*	-	-	-	-	-	-	-	-	-	**0.4419**	-	-
						-	-	-	-	-	*0.4303*		
Weed shiner	*Notropis texanus*	-	-	-	-	-	-	-	-	-	**0.1163**	-	-
		-	-	-	-	-	-	-	-	-	*0.1163*	-	
Mimic shiner	*Notropis volucellus*	**2.0769**	**2.3093**	**0.2000**	**5.0000**	-	-	-	-	**52.2727**	**436.0349**	**16.2955**	**13.6964**
		0.9354	*0.6130*	*0.2000*	*1.6867*	-	-	-	-	*27.4423*	*355.3748*	*5.2467*	*3.6752*
Channel shiner	*Notropis wickliffi*	**0.8205**	**0.7113**	**0.5000**	**3.3250**	-	-	-	-	**10.9773**	**10.8140**	**19.3409**	**20.1250**
		0.7169	*0.2041*	*0.3416*	*1.5934*	-	-	-	-	*4.3478*	*5.7855*	*8.8774*	*11.1032*
Pugnose minnow	*Opsopoeodus emiliae*	-	**0.0619**	-	-	-	-	-	-	**0.3182**	**0.5581**	**0.0227**	**0.0357**
		-	*0.0435*		-	-	-	-	-	*0.1207*	*0.3778*	*0.0227*	*0.0251*
Suckermouth minnow	*Phenacobius mirabilis*	-	-	-	-	-	-	-	-	**0.0227**	-	**0.0455**	**0.0089**
		-			-	-	-	-	-	*0.0227*	-	*0.0455*	*0.0089*
Bluntnose minnow	*Pimephales notatus*	-	-	-	-	-	-	-	-	**0.0277**	**0.5116**	-	**0.0089**
		-			-	-	-	-	-	*0.0277*	*0.4767*	-	*0.0089*
Fathead minnow	*Pimephales promelas*	-	-	-	-	-	-	-	-	**0.0227**	**0.0116**	**0.0227**	**0.0179**
		-		-	-	-	-	-	-	*0.0227*	*0.0116*	*0.0227*	*0.0126*
Bullhead minnow	*Pimephales vigilax*	**0.5897**	-	**0.5000**	**1.7000**	-	-	-	-	**4.2273**	**5.2674**	**3.5455**	**2.3125**
		0.1750	-	*0.2236*	*0.4504*	-	-	-	-	*1.7814*	*2.3416*	*0.9141*	*0.4472*
Creek chub	*Semotilus atromaculatus*	-	-	-	-	-	-	-	-	**0.0227**	-	-	-
		-	-	-	-	-	-	-	-	*0.0227*	-	-	
River carpsucker	*Carpiodes carpio*	**0.5385**	**0.2680**	**5.9000**	**2.6000**	**0.0714**	**0.1494**	-	-	**1.4545**	**7.3837**	**0.9773**	**3.7412**
		0.2040	*0.1204*	*3.0494*	*2.2022*	*0.0714*	*0.0579*	-	-	*1.3865*	*6.7859*	*0.4476*	*1.8295*
Quillback	*Carpiodes cyprinus*	**0.0513**	**0.1237**	**2.0000**	**0.8500**	-	**0.0230**	-	-	-	**0.0116**	-	**0.0625**
		0.0358	*0.0609*	*0.8692*	*0.2921*	-	*0.0162*	-	-	-	*0.0116*	-	*0.0318*
Highfin carpsucker	*Carpiodes velifer*	**0.3589**	**0.3402**	**6.7000**	**0.8500**	-	-	-	-	-	**0.1163**	-	**0.0714**
		0.1492	*0.1758*	*3.3100*	*0.5791*	-	-	-	-	-	*0.0956*	-	*0.0563*
White sucker	*Catostomus commersoni*	-	-	**0.1000**	-	-	-	-	-	-	-	-	-
		-	-	*0.1000*	-	-	-	-	-	-	-	-	-
Blue sucker	*Cycleptus elongatus*	**0.0256**	**0.0206**	-	-	-	-	-	-	-	-	-	-
		0.0256	*0.0145*	-	-	-	-	-	-	-	-	-	-
Northern hog sucker	*Hypentelium nigricans*	**0.0256**	-	-	-	-	-	-	-	-	-	-	-
		0.0256		-	-	-	-	-	-	-	-	-	-
Smallmouth buffalo	*Ictiobus bubalus*	**0.3333**	**0.3196**	**4.2000**	**0.4750**	**2.7857**	**3.3793**	**0.7826**	**0.2597**	-	**0.1860**	**0.1818**	**0.1071**
		0.0925	*0.1248*	*2.6575*	*0.1240*	*0.9061*	*0.6256*	*0.4827*	*0.1146*	-	*0.1747*	*0.1818*	*0.0909*
Bigmouth buffalo	*Ictiobus cyprinellus*	**0.4359**	**0.3196**	**0.9000**	**0.2750**	-	-	-	-	-	-	-	**0.0089**
		0.2864	*0.1582*	*0.4069*	*0.0945*	-	-	-	-	-	-	-	*0.0089*
Black buffalo	*Ictiobus niger*	**0.0256**	**0.0206**	**0.1000**	**0.1250**	-	-	-	-	-	-	-	-
		0.0256	*0.0145*	*0.1000*	*0.0639*	-	-	-	-	-	-	-	-
Spotted sucker	*Minytrema melanops*	-	-	**0.1000**	**0.0500**	-	-	-	-	-	-	-	-
		-	-	*0.1000*	*0.0349*	-	-	-	-	-	-	-	-
Silver redhorse	*Moxostoma anisurum*	**0.0769**	-	**0.4000**		-	-	-	-	-	-	-	-
		0.0567	-	*0.2211*	-	-	-	-	-	-	-	-	-
Golden redhorse	*Moxostoma erythrurum*	**0.1538**	**0.0825**	**0.2000**	**0.5000**	-	-	-	-	-	-	-	**0.0089**
		0.0865	*0.0349*	*0.2000*	*0.3755*	-	-	-	-	-	-	-	*0.0089*
Shorthead redhorse	*Moxostoma macrolepidotum*	**1.2051**	**0.9691**	**3.6000**	**5.9750**	**0.0714**	**0.1954**	-	**0.1299**	-	**0.1279**	**0.7500**	**0.1161**
		0.4077	*0.3055*	*0.8055*	*1.0570*	*0.0714*	*0.0563*	-	*0.0428*	-	*0.0398*	*0.7500*	*0.0453*
Unidentified sucker	*Unidentified Catostomidae*	-	**0.0103**	-	**0.2250**	-	-	-	-	**0.1591**	**0.1977**	**0.1591**	**0.2857**
		-	*0.0103*	-	*0.1581*	-	-	-	-	*0.0857*	*0.0807*	*0.0857*	*0.2228*
Black bullhead	*Ameiurus melas*	-	-	-	-	-	-	-	-	**0.0455**	**0.0814**	-	-
		-		-	-	-	-	-	-	*0.0318*	*0.0706*	-	
Yellow bullhead	*Ameiurus natalis*	-	-	**0.1000**	-	-	-	-	-	-	-	-	-
		-	-	*0.1000*	-	-	-	-	-	-	-	-	-
Channel catfish	*Ictalurus punctatus*	**1.0513**	**0.6186**	**0.1300**	**2.2000**	**0.7143**	**0.4600**	**16.0000**	**11.0650**	**0.1136**	**0.4535**	**1.4545**	**0.9375**
		0.2490	*0.0966*	*0.5175*	*0.6814*	*0.3739*	*0.1506*	*6.4905*	*7.5983*	*0.0583*	*0.1410*	*0.6283*	*0.4872*
Stonecat	*Noturus flavus*	-	-	-	**0.0250**	-	-	-	-	-	**0.0116**	-	-
		-	-	-	*0.0250*	-	-	-	-	-	*0.0116*	-	
Tadpole madtom	*Noturus gyrinus*	-	**0.0103**	-	**0.0500**	-	-	-	-	**0.0682**	**0.1860**	**0.0682**	**0.0982**
		-	0.0103	-	0.0349	-	-	-	-	0.0682	0.0585	0.0503	0.0380
Flathead catfish	*Pylodictis olivaris*	**0.3333**	**0.3814**	**0.0000**	**0.5000**	**0.2500**	**0.1609**	**0.0870**	**0.1948**	**0.0455**	**0.0930**	-	-
		0.1237	*0.0795*	*0.6960*	*0.1476*	*0.1511*	*0.0459*	*0.0601*	*0.0524*	*0.0318*	*0.0356*	-	-
Grass pickerel	*Esox americanus vermiculatus*	-	-	-	-	-	-	-	-	-	**0.0116**	-	-
		-	-	-	-	-	-	-	-	-	*0.0116*	-	-
Northern pike	*Esox lucius*	-	**0.0722**	-	**0.0500**	-	-	-	-	**0.0455**	**0.0116**	-	**0.0089**
		-	*0.0302*	-	*0.0349*	-	-	-	-	*0.0455*	*0.0116*	-	*0.0089*
Brook silverside	*Labidesthes sicculus*	**0.1282**	**0.1340**	**0.2000**	**0.7750**	-	-	-	-	**0.1591**	**0.0465**	**1.2955**	**1.5714**
		0.0751	*0.0455*	*0.2000*	*0.2415*	-	-	-	-	*0.1377*	*0.0282*	*0.6417*	*0.4107*
Brook stickleback	*Culaea inconstans*	-	-	-	-	-	-	-	-	-	**0.0116**	-	**0.0179**
		-	-	-	-	-	-	-	-	-	*0.0116*	-	*0.0179*
White bass	*Morone chrysops*	**2.0000**	**2.8144**	**12.7000**	**7.5250**	**0.3571**	**0.2299**	**0.0870**	**0.2987**	**1.1818**	**4.8256**	**1.5227**	**1.9107**
		0.4041	*0.7801*	*3.2933*	*1.0573*	*0.1870*	*0.0762*	*0.0870*	*0.1974*	*0.6323*	*2.9071*	*0.4332*	*0.4844*
Yellow bass	*Morone mississippiensis*	**0.0256**	-	**0.1000**	**0.1750**	-	-	-	-	-	-	-	-
		0.0256	-	*0.1000*	*0.1126*	-	-	-	-	-	-	-	-
Rock bass	*Ambloplites rupestris*	**0.0256**	**0.2887**	-	**0.0750**	-	-	-	**0.0519**	-	**0.0581**	-	-
		0.0256	*0.1487*	-	*0.0422*	-	-	-	*0.0519*	-	*0.0345*	-	-

Table 5. Continued.

	Gear:	Day electrofishing		Night electrofishing		Large hoop netting		Small hoop netting		Minnow fyke netting		Seining	
	effort (n):	39	97	10	40	28	87	23	77	44	86	44	112
Common name	Genus species	P	U	P	U	P	U	P	U	P	U	P	U
Green sunfish	*Lepomis cyanellus*	**0.0256**	**0.0206**	-	-	-	-	-	-	**0.0682**	**0.0465**	-	-
		0.0256	*0.0145*	-	-	-	-	-	-	*0.0503*	*0.0282*	-	-
Pumpkinseed	*Lepomis gibbosus*	**0.1282**	**0.0928**	-	**0.1750**	-	**0.0115**	**0.0870**	**0.0130**	**0.2045**	**0.0930**	**0.0455**	**0.0446**
		0.0655	*0.0330*	-	*0.0706*	-	*0.0115*	*0.0870*	*0.0130*	*0.1401*	*0.0356*	*0.0455*	*0.0196*
Warmouth	*Lepomis gulosus*	**0.0256**	**0.0103**	-	-	-	-	-	-	**0.0227**	**0.0116**	-	**0.0089**
		0.0256	*0.0103*	-	-	-	-	-	-	*0.0227*	*0.0116*	-	*0.0089*
Orangespotted sunfish	*Lepomis humilis*	**0.1026**	**0.2990**	**0.5000**	**0.5250**	-	-	-	-	**0.7727**	**0.3023**	**0.0227**	**0.2321**
		0.0614	*0.0720*	*0.3416*	*0.1825*	-	-	-	-	*0.2153*	*0.0741*	*0.0227*	*0.0851*
Bluegill	*Lepomis macrochirus*	**2.5385**	**2.0206**	**3.9000**	**6.6750**	**0.1071**	**0.1724**	**0.1304**	**0.4545**	**29.3182**	**5.6512**	**0.9091**	**1.8839**
		0.6641	*0.4771*	*2.2825*	*1.6229*	*0.0787*	*0.0735*	*0.0954*	*0.1450*	*13.0436*	*1.3431*	*0.4798*	*0.9184*
Bluegill x orangespotted sunfish	*L. macrochirus x humilis*	-	-	-	-	-	-	-	-	-	**0.0116**	-	-
		-	-	-	-	-	-	-	-	-	*0.0116*	-	-
Smallmouth bass	*Micropterus dolomieu*	**0.3589**	**0.5464**	**0.7000**	**0.4500**	-	**0.0115**	-	-	-	-	-	**0.0446**
		0.1245	*0.1294*	*0.3350*	*0.1474*	-	*0.0115*	-	-	-	-	-	*0.0196*
Largemouth bass	*Micropterus salmoides*	**2.8462**	**3.6804**	**2.1000**	**2.7750**	-	-	-	**0.0130**	**1.2045**	**0.5000**	**0.2955**	**1.1786**
		0.4936	*0.6497*	*0.8876*	*0.5145*	-	-	-	*0.0130*	*0.5378*	*0.1749*	*0.1856*	*0.6607*
White crappie	*Pomoxis annularis*	**0.1026**	**0.0515**	**0.3000**	**0.1000**	-	**0.0345**	**0.0435**	**0.0260**	**0.1136**	**0.1047**	-	**0.0357**
		0.0492	*0.0226*	*0.3000*	*0.0480*	-	*0.0256*	*0.0435*	*0.0260*	*0.0583*	*0.0722*	-	*0.0282*
Black crappie	*Pomoxis nigromaculatus*	**0.1025**	**0.1443**	**0.7000**	**0.5500**	**0.0714**	**0.0805**	**0.0435**	**0.0390**	**0.2045**	**0.1395**	**0.0227**	**0.0446**
		0.0614	*0.0548*	*0.3000*	*0.1289*	*0.0714*	*0.0408*	*0.0435*	*0.0390*	*0.1006*	*0.0443*	*0.0227*	*0.0233*
Western sand darter	*Ammocrypta clara*	-	-	-	**0.0250**	-	-	-	-	-	-	**0.3409**	**0.0714**
		-	-	-	*0.0250*	-	-	-	-	-	-	*0.2366*	*0.0415*
Mud darter	*Etheostoma asprigene*	**0.0513**	**0.0412**	-	-	-	-	-	-	**0.2727**	**0.7907**	**1.6591**	**0.0982**
		0.0358	*0.0203*	-	-	-	-	-	-	*0.2091*	*0.7214*	*1.6360*	*0.0507*
Johnny darter	*Etheostoma nigrum*	**0.0256**	**0.0309**	**0.1000**	**0.0750**	-	-	-	-	**0.2727**	**0.3605**	**1.0909**	**0.6339**
		0.0256	*0.0177*	*0.1000*	*0.0422*	-	-	-	-	*0.1047*	*0.1109*	*0.3199*	*0.1300*
Yellow perch	*Perca flavescens*	**0.0769**	**0.0619**	-	-	-	-	-	-	**0.0227**	-	-	**0.0179**
		0.0769	*0.0286*	-	-	-	-	-	-	*0.0227*	-	-	*0.0126*
Logperch	*Percina caprodes*	**0.4359**	**0.4639**	**0.7000**	**0.6750**	-	-	-	-	**0.3409**	**0.1744**	**0.3409**	**0.1964**
		0.2744	*0.1626*	*0.4230*	*0.2218*	-	-	-	-	*0.1377*	*0.0473*	*0.1557*	*0.6607*
Slenderhead darter	*Percina phoxocephala*	**0.0256**	**0.0206**	**0.1000**	**0.0500**	-	-	-	-	-	**0.0116**	-	**0.0089**
		0.0256	*0.0145*	*0.1000*	*0.0349*	-	-	-	-	-	*0.0116*	-	*0.0089*
River darter	*Percina shumardi*	-	**0.0412**	**0.1000**	**0.1750**	-	-	-	-	**0.5227**	**1.6744**	**0.7273**	**0.5714**
		-	*0.0250*	*0.1000*	*0.1067*	-	-	-	-	*0.3076*	*0.9957*	*0.2785*	*0.1819*
Sauger	*Sander canadense*	**1.1282**	**0.8144**	**11.7000**	**6.5750**	**0.0357**	-	-	**0.0130**	**0.1364**	**0.1512**	**0.0227**	**0.0179**
		0.4396	*0.2000*	*3.8874*	*1.4841*	*0.0357*	-	-	*0.0130*	*0.0616*	*0.0454*	*0.0227*	*0.0126*
Walleye	*Sander vitreus*	**0.3589**	**0.3814**	**4.6000**	**2.4000**	-	**0.0575**	-	**0.0130**	**0.1818**	**0.1047**	**0.1591**	**0.1250**
		0.1132	*0.0932*	*1.1470*	*0.4972*	-	*0.0473*	-	*0.0130*	*0.1042*	*0.0406*	*0.0293*	*0.0404*
Freshwater drum	*Aplodinotus grunniens*	**1.7436**	**2.3196**	**24.8000**	**14.2250**	**2.7500**	**1.0805**	**1.0000**	**1.0390**	**1.3636**	**5.3372**	**3.3409**	**4.6786**
		0.4070	*0.4465*	*6.6563*	*3.2733*	*1.6464*	*0.3129*	*0.4356*	*0.3018*	*0.6936*	*2.5570*	*1.8219*	*1.9770*

Table 6. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for day electrofishing within La Grange Reach, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Gizzard Shad	127.11	266.52	5.41	1.12	10.06	10.06
Emerald shiner	12.3	9.52	3.76	1.19	7	17.07
Freshwater Drum	2.95	4.28	3.14	1.15	5.84	22.91
Threadfin shad	6.18	3.12	3.09	1.02	5.75	28.66
Skipjack herring	5.66	4.32	3.09	1.11	5.75	34.41
White bass	8.47	6.1	2.99	1.13	5.57	39.98
White crappie	5.9	5.37	2.95	1.07	5.48	45.46
Smallmouth buffalo	2.59	2.1	2.83	1.12	5.27	50.74
Channel catfish	1.23	1.98	2.69	1.06	5.01	55.75
Black crappie	1.11	0.66	2.31	1.01	4.3	60.04
Bluegill	0.83	0.74	1.98	0.89	3.69	63.73
Largemouth bass	1.02	0.57	1.9	0.85	3.53	67.26
Bigmouth Buffalo	1.02	0.7	1.88	0.82	3.5	70.76
River carpsucker	0.89	0.51	1.83	0.81	3.4	74.16
Shortnose gar	0.2	0.26	1.1	0.61	2.05	76.21
Flathead Catfish	0.19	0.24	1.03	0.6	1.93	78.13
Silver chub	0.29	0.11	0.91	0.5	1.7	79.84
Shorthead Redhorse	0.29	0.15	0.81	0.49	1.51	81.34

Table 7. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for hoop netting within La Grange Reach, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Common carp	9.42	10.48	12.75	1.05	21.95	21.95
Channel catfish	11.47	7.63	12.56	1.1	21.62	43.57
Smallmouth buffalo	5.45	5.01	11.76	1.08	20.23	63.8
Freshwater Drum	1.18	0.38	6.8	0.76	11.7	75.5
Flathead Catfish	0.17	0.13	2.66	0.48	4.58	80.08

Table 8. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for minnow fyke netting within La Grange Reach, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Gizzard shad	460.78	640.75	6.9	1.16	11.09	11.09
Emerald shiner	54.09	248.1	6.26	1.25	10.07	21.15
White bass	15.24	25.25	3.75	1.03	6.02	27.17
Freshwater Drum	24.2	3.51	3.41	1.04	5.49	32.66
Bluegill	21.47	2.97	3.34	1.09	5.37	38.04
Channel catfish	2.63	2.86	2.93	1.03	4.72	42.75
White crappie	2.62	5.75	2.49	0.85	4.01	46.76
Threadfin shad	66.62	1.44	2.28	0.66	3.66	50.42
Common carp	3.68	7.07	2.2	0.72	3.53	53.95
Black crappie	1.71	1.1	2.05	0.78	3.29	57.25
Silverband shiner	0.69	1.9	1.94	0.7	3.12	60.37
Bullhead minnow	1.23	0.92	1.85	0.79	2.97	63.34
Shortnose gar	0.78	1.58	1.82	0.71	2.93	66.27
Sauger	0.33	0.93	1.76	0.72	2.83	69.1
Red shiner	0.88	1.85	1.75	0.65	2.81	71.91
Largemouth bass	0.88	1.19	1.61	0.76	2.59	74.5
Western mosquitofish	1.22	17.71	1.58	0.57	2.55	77.04
Black Bullhead	9.68	0.17	1.08	0.53	1.73	78.78
Golden Shiner	0.43	1.31	1.04	0.57	1.68	80.45

Table 9. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for seining within La Grange Reach, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Gizzard shad	155.14	91.6	9.94	1.24	15.43	15.43
Emerald shiner	45.1	36.9	6.96	1.14	10.81	26.24
White bass	3.54	3.63	5.47	1.01	8.49	34.73
Threadfin shad	10.32	0.73	3.47	0.73	5.39	40.12
Freshwater Drum	2.76	0.4	3.34	0.8	5.19	45.31
Bluegill	2.58	1.57	3.27	0.83	5.08	50.38
White crappie	3.73	1.1	2.86	0.7	4.44	54.82
Bullhead minnow	0.9	0.27	2.39	0.62	3.71	58.53
Channel catfish	1.04	0.07	2.38	0.61	3.7	62.23
Black crappie	0.73	0.3	2.28	0.66	3.55	65.78
Smallmouth buffalo	0.42	0.43	2.22	0.62	3.44	69.22
Silverband shiner	0.5	0.27	1.92	0.51	2.99	72.21
Western mosquitofish	0.62	0.23	1.86	0.57	2.89	75.1
Red shiner	0.67	0.23	1.56	0.45	2.43	77.53
Largemouth bass	0.19	0.17	1.28	0.52	1.99	79.52
River carpsucker	0.14	0.13	1.27	0.44	1.97	81.49

Table 10. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for day electrofishing within Pool 13, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Gizzard shad	14.06	10.44	3.81	1.19	6.83	6.83
Emerald shiner	31.35	38.67	3.33	1.15	5.97	12.8
River shiner	4.67	4.15	2.93	1.17	5.25	18.06
Largemouth bass	3.68	2.85	2.52	1.07	4.53	22.59
Spotfin shiner	2.52	1.72	2.52	1.08	4.52	27.11
Bluegill	2.02	2.54	2.52	1.16	4.52	31.63
White crappie	2.32	1.74	2.52	1.11	4.52	36.15
White bass	2.81	2	2.44	1.13	4.37	40.52
Common carp	9.26	10.69	2.4	0.99	4.3	44.82
Black crappie	0.97	1.21	2.08	0.93	3.73	48.55
Channel catfish	0.62	1.05	2	1.01	3.59	52.14
Sauger	0.81	1.13	1.95	0.97	3.51	55.65
Mimic shiner	2.31	2.08	1.9	0.67	3.41	59.06
Bullhead minnow	0.69	0.59	1.59	0.83	2.86	61.92
Smallmouth bass	0.55	0.36	1.36	0.72	2.45	64.37
Flathead Catfish	0.38	0.33	1.34	0.73	2.4	66.77
Walleye	0.38	0.36	1.3	0.73	2.33	69.1
Silver chub	0.69	0.31	1.3	0.7	2.33	71.43
Smallmouth buffalo	0.32	0.33	1.22	0.72	2.19	73.62
Channel shiner	0.71	0.82	1.13	0.58	2.03	75.65
River carpsucker	0.27	0.54	1.13	0.64	2.03	77.68
Highfin carpsucker	0.34	0.36	0.99	0.55	1.77	79.45
Longnose gar	0.12	0.28	0.93	0.49	1.67	81.12

Table 11. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for night electrofishing within Pool 13, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Freshwater drum	24.8	14.23	9.14	1.28	13.54	13.54
Common carp	10.8	6.95	5.45	0.65	8.07	21.61
Gizzard shad	10	6.43	4.99	0.83	7.39	29.01
Emerald shiner	3.6	13.3	4.84	0.61	7.17	36.17
Sauger	11.7	6.58	4.69	1.04	6.95	43.12
White bass	12.7	7.53	4.59	1.42	6.8	49.92
Bluegill	3.9	6.68	3.25	0.93	4.82	54.73
River carpsucker	5.9	2.6	3.14	0.55	4.66	59.39
Highfin carpsucker	6.7	0.85	2.68	0.79	3.97	63.36
Mimic shiner	0.2	5	2.35	0.51	3.48	66.84
Shorthead redhorse	3.6	5.98	2.32	1.02	3.43	70.28
Walleye	4.6	2.4	1.99	1.36	2.94	73.22
Largemouth bass	2.1	2.78	1.64	0.84	2.43	75.65
Smallmouth buffalo	4.2	0.48	1.53	0.59	2.26	77.91
Mooneye	2.2	0.45	1.46	0.41	2.16	80.07

Table 12. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for hoop netting within Pool 13, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Channel catfish	5.68	7.92	18.1	1.07	24.33	24.33
Smallmouth buffalo	2	1.96	15.43	0.93	20.74	45.07
Freshwater Drum	1.11	2.04	13.19	0.93	17.73	62.8
Flathead Catfish	0.18	0.18	5.91	0.51	7.94	70.74
White bass	0.27	0.24	4.85	0.5	6.52	77.27
Bluegill	0.32	0.12	3.9	0.41	5.24	82.51

Table 13. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for minnow fyke netting within Pool 13, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Mimic shiner	436.03	52.27	6.66	0.9	9.22	9.22
River shiner	34.71	8.91	5.97	1.16	8.27	17.49
Emerald shiner	30.48	22.39	5.95	1.16	8.24	25.73
Bluegill	5.65	29.32	5.68	1.09	7.87	33.6
Channel shiner	10.81	10.98	4.61	0.86	6.38	39.99
Bullhead minnow	5.27	4.23	4.13	1.05	5.72	45.71
White crappie	2.45	2.14	3.7	1	5.13	50.84
Freshwater Drum	5.34	1.36	3.08	0.76	4.27	55.11
White bass	4.83	1.18	2.66	0.8	3.69	58.8
Black crappie	0.3	0.77	2.4	0.76	3.33	62.13
Largemouth bass	0.5	1.2	2.18	0.68	3.02	65.15
Common carp	1.05	1.84	1.76	0.44	2.43	67.58
River darter	1.67	0.52	1.72	0.52	2.38	69.96
Spotail shiner	0.72	1.82	1.59	0.61	2.2	72.16
Channel catfish	0.45	0.11	1.46	0.53	2.03	74.19
Johnny darter	0.36	0.27	1.46	0.54	2.02	76.21
Shortnose gar	0.41	0.27	1.44	0.53	2	78.21
Pugnose minnow	0.56	0.32	1.26	0.47	1.75	79.95
Logperch	0.17	0.34	1.19	0.55	1.65	81.6

Table 14. Average abundance, average dissimilarity, dissimilarity standard deviation, contribution to community dissimilarity, and cumulative dissimilarity as predicted by SIMPER (Primer E, 2001) at placed and unplaced sites for seining within Pool 13, LTRMP main channel habitats 1993-2004.

Species	Average Abundance Un-placed sites	Average Abundance Placed sites	Average Dissimilarity	Dissimilarity Standard Deviation	Contribution%	Cumulative%
Mimic shiner	13.82	16.3	7.11	0.88	11.36	11.36
Channel shiner	20.31	19.34	6.93	1.11	11.08	22.44
River shiner	72.3	62.75	6.84	1.19	10.93	33.37
Spotfin shiner	2.98	2.57	4.34	1.07	6.94	40.31
White bass	1.93	1.52	4.07	0.98	6.51	46.82
Freshwater Drum	4.72	3.34	3.91	0.87	6.25	53.06
White crappie	0.64	1.09	3.16	0.86	5.06	58.12
Silver chub	1.18	1.86	2.87	0.68	4.59	62.71
Channel catfish	0.95	1.45	2.83	0.71	4.53	67.24
Black crappie	1.9	0.91	2.68	0.69	4.29	71.52
River carpsucker	3.77	0.98	2.19	0.55	3.5	75.02
River darter	0.58	0.73	2.11	0.64	3.38	78.4
Largemouth bass	1.19	0.3	1.84	0.58	2.94	81.35

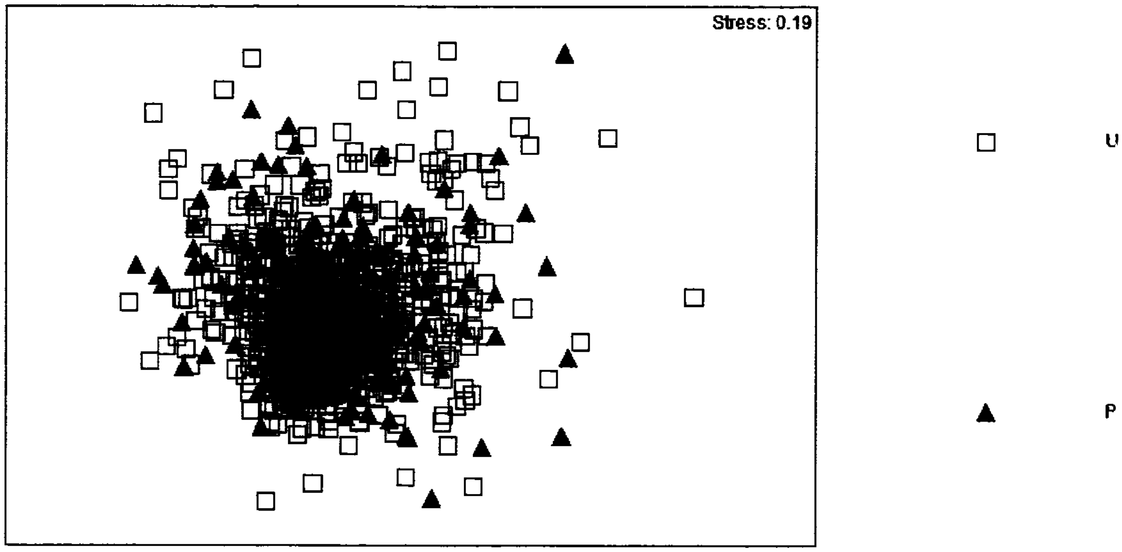


Figure 2. Non-metric multidimensional scaling plot of fish assemblage structure (species presence-absence, all gears combined) of La Grange Reach, Illinois Waterway as collected by the Long Term Resource Monitoring Program 1993-2004 on modern (1990-2003) dredge material placement sites (P) and un-placed sites (U).

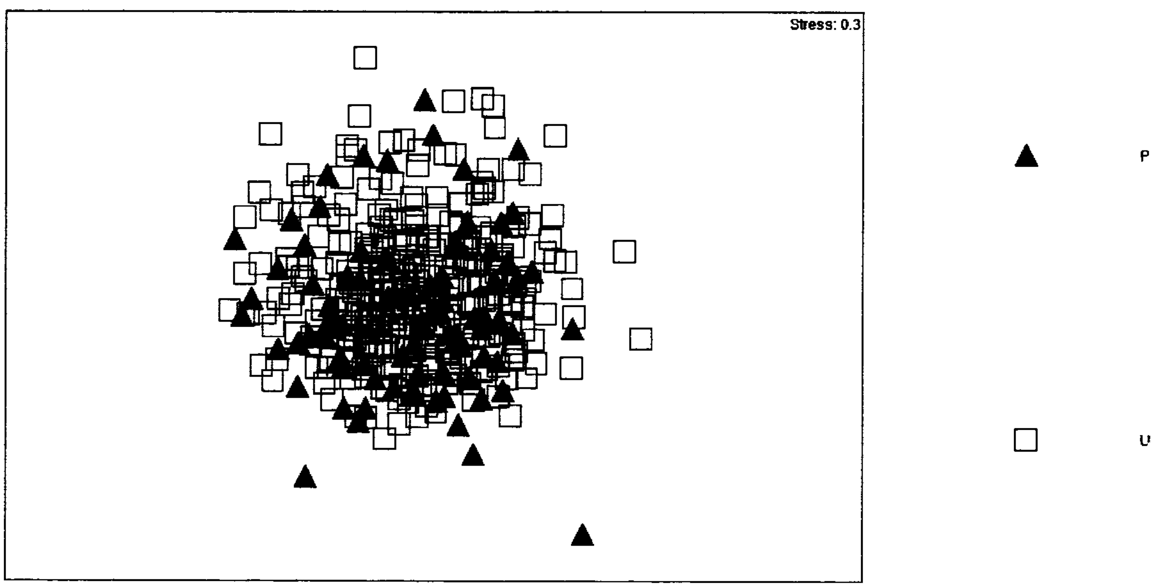


Figure 3. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, day electrofishing only) of La Grange Reach, Illinois Waterway as collected by the Long Term Resource Monitoring Program 1993-2004 on modern (1990-2003) dredge material placement sites (P) and un-placed sites (U).

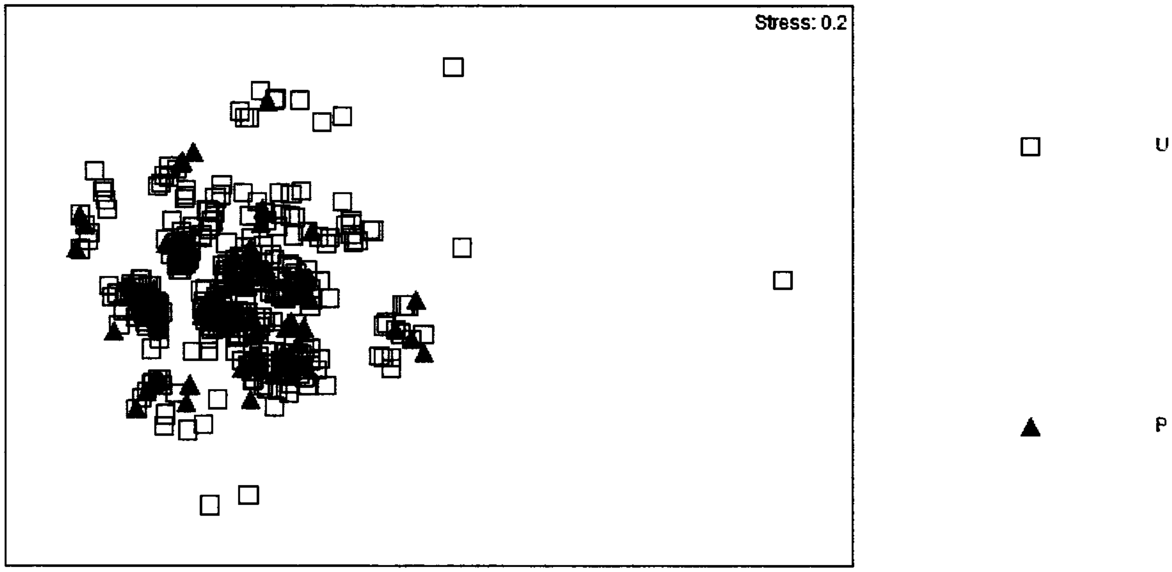


Figure 4. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, Large and small hoop netting only) of La Grange Reach, Illinois Waterway as collected by the Long Term Resource Monitoring Program 1993-2004 on modern (1990-2003) dredge material placement sites (P) and un-placed sites (U).

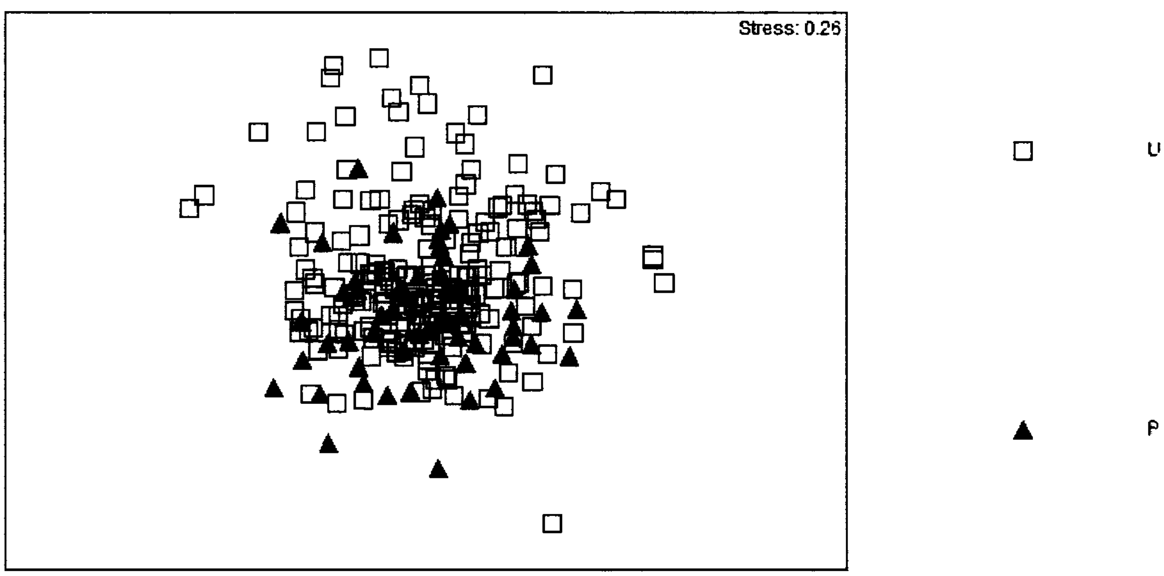


Figure 5. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, minnow fyke netting only) of La Grange Reach, Illinois Waterway as collected by the Long Term Resource Monitoring Program 1993-2004 on modern (1990-2003) dredge material placement sites (P) and un-placed sites (U).

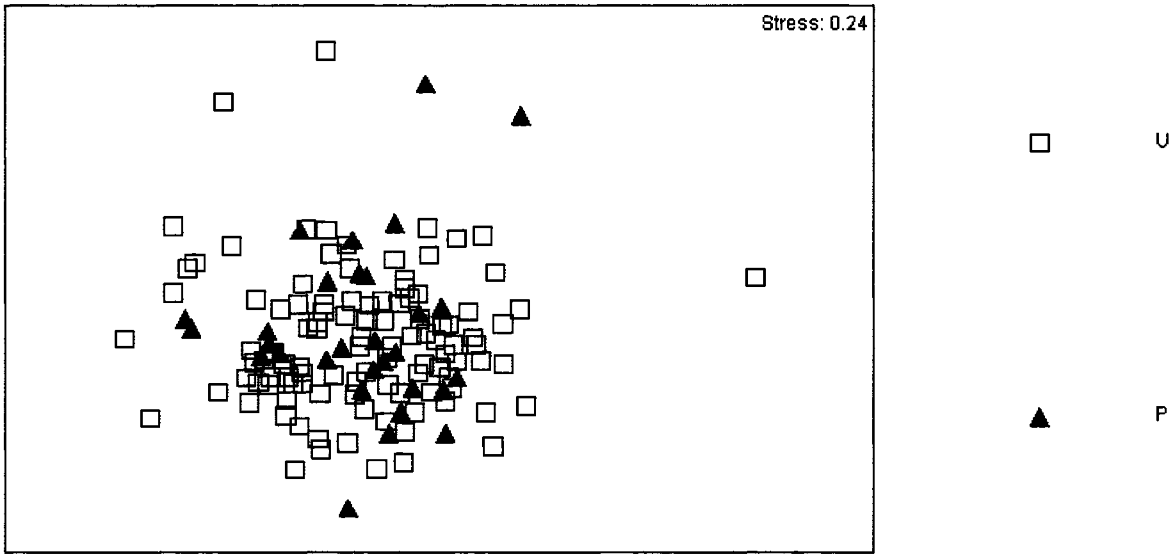


Figure 6. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, seining only) of La Grange Reach, Illinois Waterway as collected by the Long Term Resource Monitoring Program 1993-2004 on modern (1990-2003) dredge material placement sites (P) and un-placed sites (U).

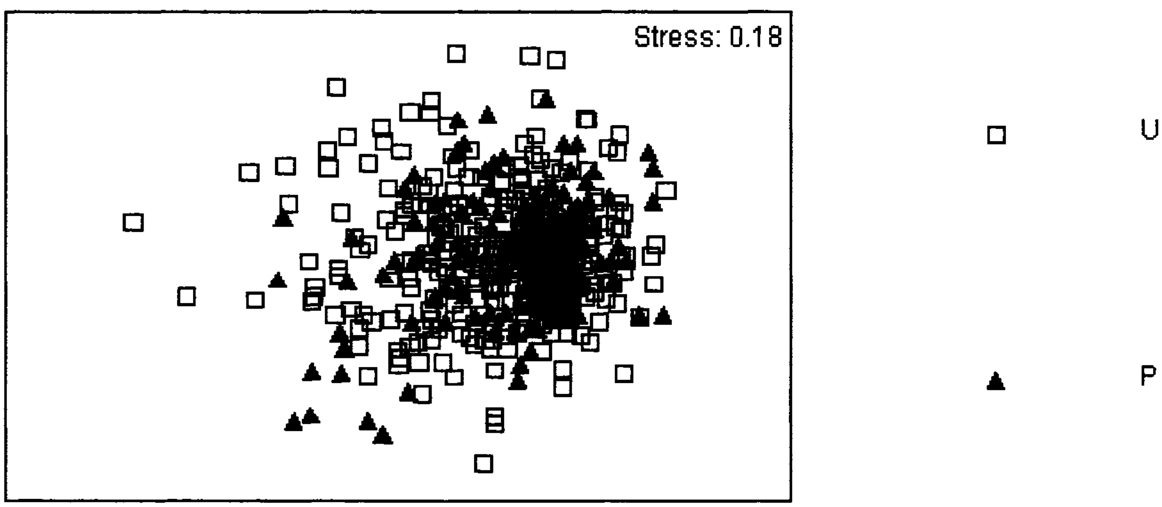


Figure 7. Non-metric multidimensional scaling plot of fish assemblage structure (species presence-absence, all gears combined) of Pool 13, Mississippi River as collected by the Long Term Resource Monitoring Program 1993-2004 on historical (1940-2003) dredge material placement sites (P) and un-placed sites (U).

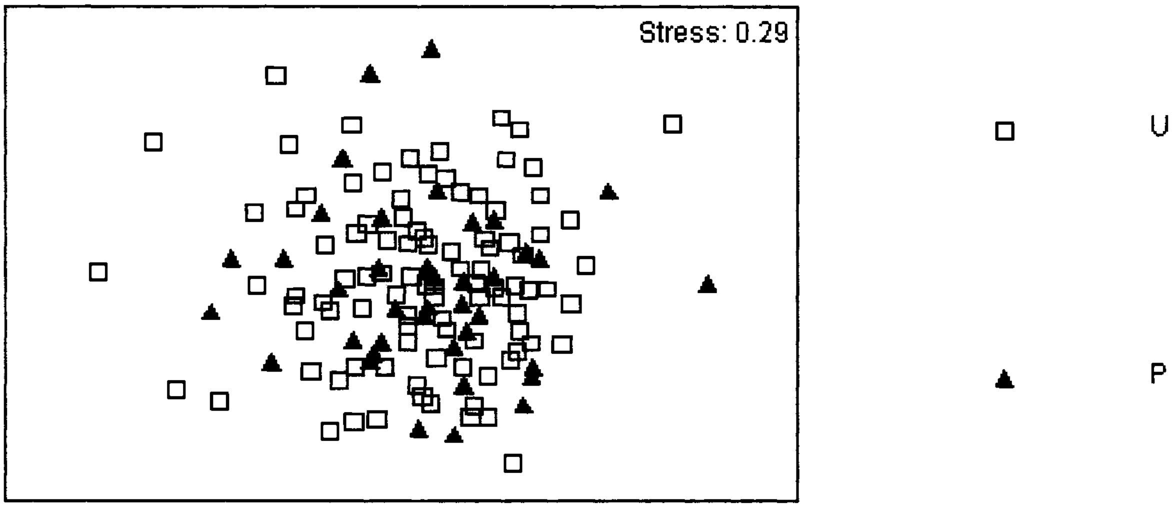


Figure 8. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, day electrofishing only) of Pool 13, Mississippi River as collected by the Long Term Resource Monitoring Program 1993-2004 on historical (1940-2003) dredge material placement sites (P) and un-placed sites (U).

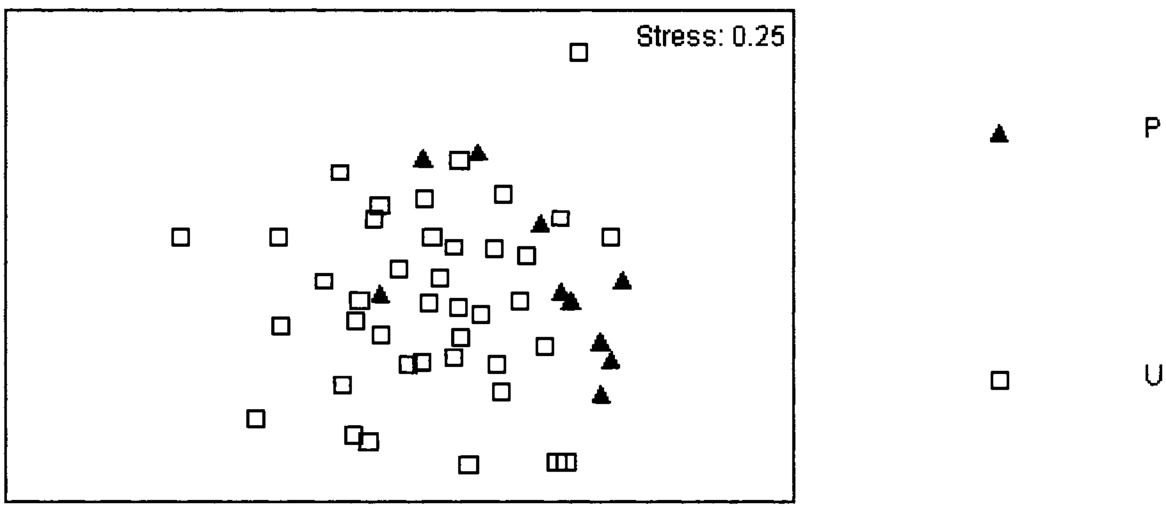


Figure 9. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, night electrofishing only) of Pool 13, Mississippi River as collected by the Long Term Resource Monitoring Program 1993-2004 on historical (1940-2003) dredge material placement sites (P) and un-placed sites (U).

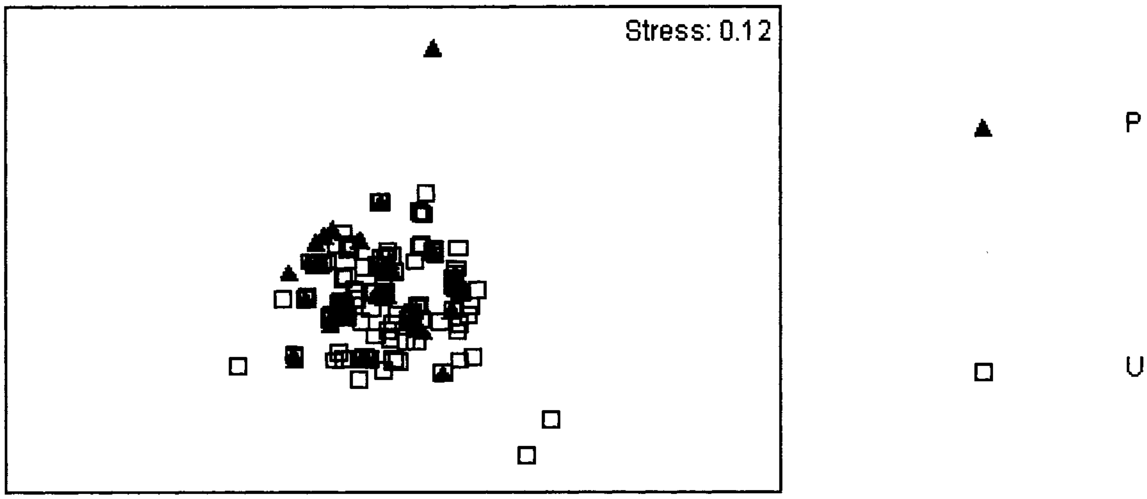


Figure 10. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, large and small hoop netting only) of Pool 13, Mississippi River as collected by the Long Term Resource Monitoring Program 1993-2004 on historical (1940-2003) dredge material placement sites (P) and un-placed sites (U).

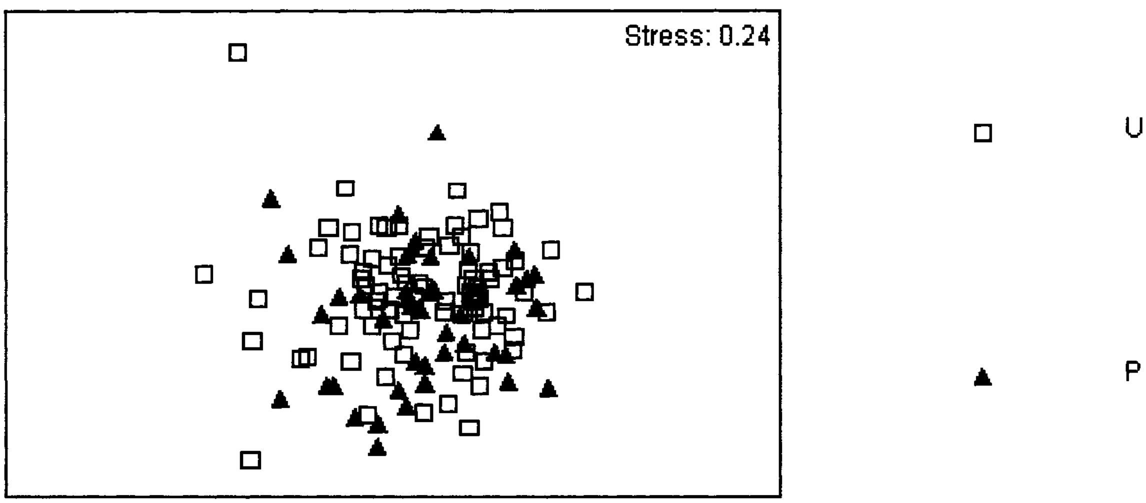
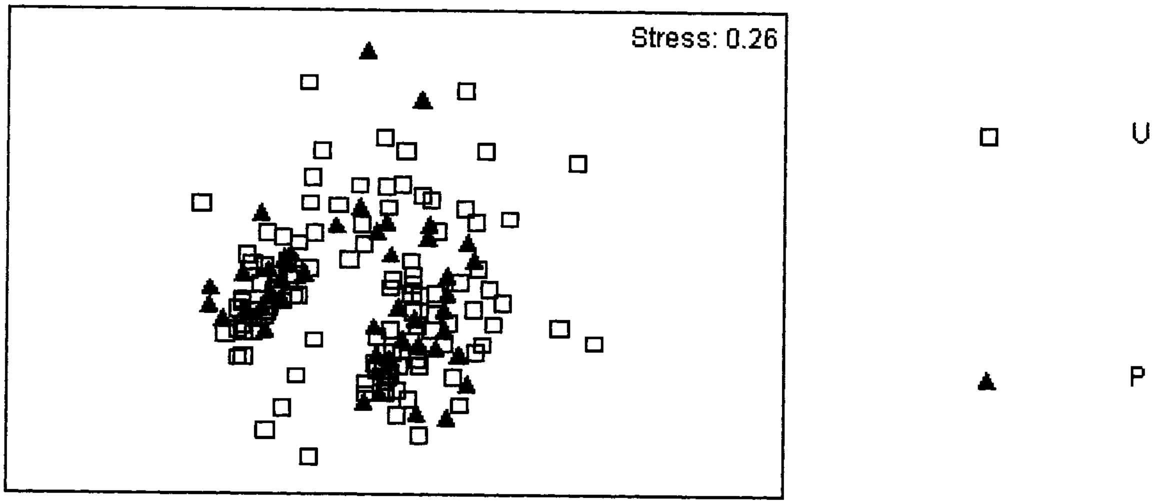


Figure 11. Non-metric multidimensional scaling plot of fish assemblage structure (fourth root transformed fish catches, minnow fyke netting only) of Pool 13, Mississippi River as collected by the Long Term Resource Monitoring Program 1993-2004 on historical (1940-2003) dredge material placement sites (P) and un-placed sites (U).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Appendix A. Power analysis

Table A.1. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from La Grange Reach, Illinois Waterway, main channel border from day electrofishing from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	Power	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Gizzard shad	**0.198**	135.970	245.740	30	351	374.940	1306.800	0.05
Emerald shiner	**0.125**	18.533	9.444	30	351	58.508	38.395	0.05
Threadfin shad	**0.146**	6.200	3.593	30	351	14.954	11.001	0.05
Bluegill	**0.065**	0.633	0.778	30	351	1.629	1.812	0.05
Common carp	**0.215**	4.200	5.558	30	351	5.792	7.625	0.05
White bass	**0.029**	6.733	6.604	30	351	11.262	11.038	0.05
Freshwater drum	**0.510**	2.033	4.160	30	351	5.327	7.159	0.05
Channel catfish	**0.433**	1.067	1.889	30	351	2.288	2.980	0.05
Black crappie	**0.870**	0.033	0.188	30	351	0.183	0.692	0.05
Smallmouth buffalo	**0.383**	1.467	2.239	30	351	2.129	4.486	0.05
White crappie	**0.155**	0.068	0.117	30	351	0.254	0.442	0.05
Largemouth bass	**0.196**	1.367	0.607	30	351	3.634	1.223	0.05
Western mosquitofish	**1.000**	0.100	0.741	30	351	0.548	0.619	0.05
Bigmouth buffalo	**0.064**	0.967	0.758	30	351	2.456	2.335	0.05
Skipjack herring	**0.042**	5.300	4.547	30	351	16.114	17.852	0.05
River carpsucker	**0.291**	1.433	0.519	30	351	3.421	1.406	0.05
Bullhead minnow	**0.177**	1.333	0.143	30	351	6.748	0.593	0.05
Sauger	**0.267**	1.100	0.727	30	351	10.423	1.523	0.05
Shorthead redhorse	**0.174**	0.100	0.185	30	351	0.403	0.661	0.05
Black buffalo	-	0.000	0.060	30	351	0.000	0.292	0.05
Bighead carp	**0.106**	0.333	0.108	30	351	1.647	0.983	0.05
Silver carp	**0.460**	0.100	0.370	30	351	0.305	2.509	0.05

Table A.2. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from La Grange Reach, Illinois Waterway, main channel border from hoop netting from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	Power	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Common carp	**0.845**	4.517	9.549	29	474	7.895	16.739	0.05
Freshwater drum	**0.900**	0.345	1.038	29	474	0.936	2.575	0.05
Channel catfish	**0.998**	3.483	1.038	29	474	7.809	51.293	0.05
Smallmouth buffalo	**0.066**	4.241	5.228	29	474	10.924	11.093	0.05
White crappie	-	-	-	29	474	-	-	0.05
Bigmouth buffalo	**0.109**	0.035	0.008	29	474	0.186	0.092	0.05
River carpsucker	**0.425**	0.035	0.141	29	474	0.258	0.297	0.05
Black buffalo	**0.050**	0.069	0.053	29	474	0.258	0.297	0.05
Bighead carp	**0.616**	0.069	0.380	29	474	0.258	2.805	0.05
Silver carp	-	-	0.004	29	474	-	0.065	0.05

Table A.3. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from La Grange Reach, Illinois Waterway, main channel border from minnow fyke netting from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	Power	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Gizzard shad	**0.134**	1772.300	400.950	19	239	6606.700	2588.800	0.05
Emerald shiner	**0.313**	604.530	58.222	19	239	1530.400	147.860	0.05
Threadfin shad	**0.229**	2.947	55.594	19	239	7.137	666.000	0.05
Unidentified Clupeid	**0.068**	32.737	15.808	19	239	142.700	184.480	0.05
Bluegill	**0.274**	4.474	18.255	19	239	9.907	152.970	0.05
Common carp	**0.274**	1.000	4.732	19	239	2.404	41.386	0.05
White bass	**0.090**	25.053	16.993	19	239	52.913	43.308	0.05
Freshwater drum	**0.549**	3.947	20.703	19	239	7.028	121.320	0.05
Channel catfish	**0.112**	4.368	2.548	19	239	10.012	5.425	0.05
Black crappie	**0.025**	1.579	1.573	19	239	5.938	8.462	0.05
Smallmouth buffalo	**0.031**	0.105	0.113	19	239	0.315	0.449	0.05
White crappie	**0.243**	1.684	3.469	19	239	2.907	19.139	0.05
Largemouth bass	**0.243**	0.526	0.987	19	239	1.219	3.454	0.05
Western mosquitofish	**0.063**	3.105	5.153	19	239	9.809	63.529	0.05
Bigmouth buffalo	-	0.000	0.075	19	239	0.000	0.529	0.05
Unidentified sucker	**0.038**	3.895	4.418	19	239	10.650	20.314	0.05
Skipjack herring	**0.282**	0.105	0.276	19	239	0.315	1.531	0.05
River carpsucker	-	0.000	0.026	19	239	0.000	0.324	0.05
Bullhead minnow	**0.097**	1.579	1.121	19	239	2.673	4.007	0.05
Sauger	**0.080**	0.632	0.452	19	239	1.289	1.357	0.05
Shorthead redhorse	-	0.000	0.038	19	239	0.000	0.212	0.05
Black buffalo	-	0.000	0.000	19	239	0.000	0.000	0.05
Bighead carp	**0.153**	1.842	0.477	19	239	5.928	4.498	0.05
Silver carp	-	0.000	0.034	19	239	0.000	0.288	0.05

Table A.4. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from La Grange Reach, Illinois Waterway, main channel border from seining from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	**Power**	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Gizzard shad	**0.048**	173.360	135.370	14	125	424.820	431.750	0.05
Emerald shiner	**0.045**	37.286	43.288	14	125	65.194	147.660	0.05
Threadfin shad	**0.491**	0.571	8.944	14	125	1.158	47.828	0.05
Unidentified Clupeid	-	-	-	14	125	-	-	0.05
Bluegill	**0.066**	1.571	2.408	14	125	5.316	0.498	0.05
Common carp	**0.139**	0.500	0.160	14	125	1.345	0.498	0.05
White bass	**0.597**	4.286	3.424	14	125	5.757	5.878	0.05
Freshwater drum	**0.730**	0.214	2.432	14	125	0.579	9.409	0.05
Channel catfish	**0.752**	0.143	0.888	14	125	0.363	2.938	0.05
Black crappie	-	-	0.064	14	125	-	0.246	0.05
Smallmouth buffalo	**0.028**	0.429	0.416	14	125	0.756	1.101	0.05
White crappie	-	-	0.232	14	125	-	1.984	0.05
Largemouth bass	**0.039**	0.214	0.176	14	125	0.579	0.476	0.05
Western mosquitofish	**0.342**	0.214	0.560	14	125	0.579	1.715	0.05
Bigmouth buffalo	**0.054**	0.429	0.256	14	125	1.604	2.094	0.05
Unidentified sucker	-	-	0.416	14	125	-	1.733	0.05
Skipjack herring	**0.375**	0.500	3.400	14	125	0.941	19.425	0.05
River carpsucker	**0.029**	0.143	0.136	14	125	0.363	0.493	0.05
Bullhead minnow	-	-	0.832	14	125 -		2.282	0.05
Sauger	**0.150**	0.071	0.152	14	125	0.267	0.493	0.05
Shorthead redhorse	-	-	0.008	14	125	-	0.089	0.05
Black buffalo	-	-	-	14	125	-	-	0.05
Bighead carp	-	-	0.560	14	125	-	3.620	0.05
Silver carp	-	-	-	14	125	-	-	0.05

Table A.5. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from Pool 13, Mississippi River, main channel border from day electrofishing from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	**Power**	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Mimic shiner	**0.055**	2.077	2.309	39	97	5.842	6.037	0.05
Emerald shiner	**0.119**	38.667	31.351	39	97	47.373	57.924	0.05
River shiner	**0.060**	4.154	4.670	39	97	9.187	8.989	0.05
Channel shiner	**0.035**	0.821	0.711	39	97	4.477	2.010	0.05
Bluegill	**0.097**	2.539	2.021	39	97	4.148	4.699	0.05
Gizzard shad	**0.112**	10.436	14.062	39	97	24.290	27.784	0.05
Freshwater drum	**0.155**	1.744	2.320	39	97	2.541	4.398	0.05
Common carp	**0.098**	10.692	9.258	39	97	11.676	9.555	0.05
Channel catfish	**0.356**	1.051	0.619	39	97	1.555	0.951	0.05
White bass	**0.149**	2.000	2.814	39	97	2.524	7.683	0.05
River carpsucker	**0.201**	0.539	0.268	39	97	1.274	1.186	0.05
Bullhead minnow	**0.070**	0.590	0.691	39	97	1.094	1.094	0.05
Spotfin shiner	**0.220**	1.718	2.516	39	97	2.585	5.154	0.05
Largemouth bass	**0.172**	2.846	3.680	39	97	3.083	6.399	0.05
Smallmouth buffalo	**0.031**	0.333	0.320	39	97	0.577	1.229	0.05
Sauger	**0.093**	1.128	0.814	39	97	2.745	1.970	0.05
Shorthead redhorse	**0.067**	1.205	0.969	39	97	2.546	3.009	0.05
Silver chub	**0.217**	0.308	0.691	39	97	0.694	2.987	0.05
Brook silverside	**0.029**	0.128	0.134	39	97	0.469	0.448	0.05
River darter	-	-	0.041	39	97	-	0.247	0.05
Spottail shiner	**0.052**	0.205	0.247	39	97	0.570	0.830	0.05
Walleye	**0.035**	0.359	0.381	39	97	0.707	0.918	0.05
Mud darter	**0.043**	0.051	0.041	39	97	0.224	0.200	0.05
Johnny darter	**0.036**	0.026	0.031	39	97	0.160	0.174	0.05
Highfin carpsucker	**0.030**	0.359	0.340	39	97	0.932	1.731	0.05

Table A.6. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from Pool 13, Mississippi River, main channel border from night electrofishing from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	Power	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Mimic shiner	**0.778**	0.200	5.000	10	40	0.633	10.667	0.05
Emerald shiner	**0.638**	3.600	13.300	10	40	3.026	25.212	0.05
River shiner	**0.058**	2.100	1.550	10	40	3.814	3.071	0.05
Channel shiner	**0.396**	0.500	3.325	10	40	1.080	10.078	0.05
Bluegill	**0.154**	3.900	6.675	10	40	7.218	10.264	0.05
Gizzard shad	**0.079**	10.000	6.425	10	40	18.196	9.899	0.05
Freshwater drum	**0.264**	24.800	14.225	10	40	21.049	20.702	0.05
Common carp	**0.099**	10.800	6.950	10	40	16.116	6.457	0.05
Channel catfish	**0.175**	1.300	2.200	10	40	1.636	4.310	0.05
White bass	**0.227**	12.700	7.525	10	40	10.414	6.687	0.05
River carpsucker	**0.130**	5.900	2.600	10	40	9.643	13.928	0.05
Bullhead minnow	**0.895**	0.050	1.700	10	40	0.707	2.848	0.05
Spotfin shiner	**0.169**	0.200	0.425	10	40	0.422	1.060	0.05
Largemouth bass	**0.090**	2.100	2.775	10	40	2.807	3.254	0.05
Smallmouth buffalo	**0.240**	4.200	0.475	10	40	8.404	0.784	0.05
Suager	**0.204**	11.700	6.575	10	40	12.293	9.386	0.05
Shorthead redhorse	**0.414**	3.600	5.975	10	40	2.547	6.685	0.05
Silver chub	**0.033**	1.700	1.825	10	40	2.751	3.434	0.05
Brook silverside	**0.431**	0.200	0.775	10	40	0.633	1.527	0.05
River darter	**0.072**	0.100	0.175	10	40	0.316	0.675	0.05
Spottail shiner	**0.099**	0.200	0.325	10	40	0.422	0.764	0.05
Walleye	**0.401**	4.600	2.400	10	40	3.627	3.144	0.05
Mud darter		-	-	10	40	-	-	0.05
Johnny darter	**0.040**	0.100	0.075	10	40	0.316	0.174	0.05
Highfin carpsucker	**0.348**	6.700	0.850	10	40	10.467	3.662	0.05

Table A.7. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from Pool 13, Mississippi River, main channel border from hoop netting from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	**Power**	μ_1	μ_2	N_1	.	SD_1	SD_2	α
Smallmouth buffalo	**0.255**	1.882	1.915	51	164	3.973	4.569	0.05
Freshwater drum	**0.151**	1.961	1.061	51	164	6.609	2.786	0.05
Channel catfish	**0.066**	7.608	5.439	51	164	22.078	45.847	0.05
White bass	**0.037**	0.235	0.262	51	164	0.790	1.291	0.05
Flathead catfish	**0.026**	0.177	0.177	51	164	0.623	0.442	0.05
Bigmouth buffalo	-	0.000	0.006	51	164	0.000	0.078	0.05
River carpsucker	**0.121**	0.039	0.079	51	164	0.280	0.399	0.05
Common carp	**0.031**	0.039	0.037	51	164	0.196	0.219	0.05

Table A.8. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from Pool 13, Mississippi River, main channel border from minnow fyke netting from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	Power	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Mimic shiner	**0.185**	52.273	436.030	44	86	182.030	3295.600	0.05
Emerald shiner	**0.065**	22.386	30.477	44	86	75.291	128.240	0.05
River shiner	**0.599**	8.909	34.709	44	86	17.505	104.390	0.05
Channel shiner	**0.026**	10.977	10.814	44	86	28.840	53.652	0.05
Bluegill	**0.423**	29.318	5.651	44	86	86.522	12.456	0.05
Gizzard shad	**0.156**	3.864	0.233	44	86	24.860	1.014	0.05
Freshwater drum	**0.318**	1.364	5.337	44	86	4.601	23.713	0.05
Common carp	**0.068**	1.841	1.047	44	86	10.415	5.143	0.05
Channel Catfish	**0.599**	0.114	0.454	44	86	0.387	1.308	0.05
White bass	**0.227**	1.182	4.826	44	86	4.195	26.959	0.05
River carpsucker	**0.133**	1.455	7.384	44	86	9.197	62.930	0.05
Bullhead minnow	**0.054**	4.227	5.267	44	86	11.816	21.715	0.05
Spotfin shiner	**0.055**	2.136	2.454	44	86	4.118	5.566	0.05
Largemouth bass	**0.230**	1.205	0.500	44	86	3.567	1.622	0.05
Smallmouth buffalo	-	0.000	0.186	44	86	0.000	1.620	0.05
Sauger	**0.039**	0.136	0.151	44	86	0.409	0.421	0.05
Shorthead redhorse	-	0.000	0.128	44	86	0.000	0.369	0.05
Silver chub	**0.043**	0.046	0.058	44	86	0.302	0.235	0.05
Brook silverside	**0.121**	0.159	0.047	44	86	0.914	0.262	0.05
River darter	**0.194**	0.523	1.674	44	86	2.010	9.234	0.05
Spottail shiner	**0.110**	1.818	0.721	44	86	9.534	2.777	0.05
Walleye	**0.100**	0.182	0.105	44	86	0.691	0.377	0.05
Mud darter	**0.101**	0.273	0.791	44	86	1.387	6.690	0.05
Johnny darter	**0.083**	0.273	0.361	44	86	0.694	0.174	0.05
Highfin carpsucker	-	0.000	0.116	44	86	0.000	0.887	0.05

Table A.9. Statistical power of fish species collected by the Long Term Resource Monitoring Program , from Pool 13, Mississippi River, main channel border from seining from 1993-2004 based upon the mean catches (μ), sample sizes from placed (1) and unplaced (2) sites, the standard deviations of the mean catches (SD), and alpha level of detection.

Species	**Power**	μ_1	μ_2	N_1	N_2	SD_1	SD_2	α
Mimic shiner	**0.060**	16.295	13.696	44	112	34.802	38.895	0.05
Emerald shiner	**0.096**	107.550	171.050	44	112	214.420	960.040	0.05
River shiner	**0.063**	62.750	71.652	44	112	92.297	160.430	0.05
Channel shiner	**0.028**	19.341	20.125	44	112	58.887	117.510	0.05
Bluegill	**0.152**	0.909	1.884	44	112	3.183	9.719	0.05
Gizzard shad	**0.050**	1.955	2.286	44	112	4.675	7.941	0.05
River carpsucker	**0.071**	3.341	4.679	44	112	12.085	20.923	0.05
Common carp	**0.276**	0.091	0.277	44	112	0.362	1.310	0.05
Channel Catfish	**0.094**	1.455	0.938	44	112	4.168	5.156	0.05
White bass	**0.086**	1.523	1.911	44	112	2.873	5.126	0.05
River carpsucker	**0.307**	0.977	3.741	44	112	2.969	19.361	0.05
Bullhead minnow	**0.222**	3.546	2.313	44	112	6.063	4.733	0.05
Spotfin shiner	**0.042**	2.568	2.955	44	112	6.694	14.210	0.05
Largemouth bass	**0.247**	0.296	1.179	44	112	1.231	6.992	0.05
Smallmouth buffalo	**0.055**	0.182	0.107	44	112	1.206	0.962	0.05
Sauger	**0.038**	0.023	0.018	44	112	0.151	0.133	0.05
Shorthead redhorse	**0.128**	0.750	0.116	44	112	4.975	0.479	0.05
Silver chub	**0.087**	1.864	1.170	44	112	6.144	7.166	0.05
Brook silverside	**0.055**	1.296	1.571	44	112	4.257	4.347	0.05
River darter	**0.067**	0.727	0.571	44	112	1.847	1.925	0.05
Spottail shiner	**0.055**	0.409	0.304	44	112	1.716	1.381	0.05
Walleye	**0.057**	0.159	0.125	44	112	0.526	0.427	0.05
Mud darter	**0.152**	1.659	0.098	44	112	10.852	0.536	0.05
Johnny darter	**0.255**	1.091	0.634	44	112	2.122	1.375	0.05
Highfin carpsucker	-	0.000	0.071	44	112	0.000	0.596	0.17